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We made an error in manually transcribing two data points listed in table 1. Specifically, we reported

was used to generate all published figures. A corrected version of table 1 is provided here.

Table 1. Annual banking metrics (MMtCO₂e).

Metric	2013	2014	2015	2016	2017	2018
Private Bank (current vintages only)	11.9	43.1	106.6	68.3	106.5	226.9
Government holding accounts	8.0	10.4	6.6	105.9	132.1	51.0
Government reserve accounts	141.8	141.8	141.8	141.0	141.0	161.6
Total	161.7	195.3	255.1	315.2	379.6	439.5
Private bank, minimum allowances (current vintages only)	11.9	32.3	89.0	41.3	59.0	186.2
Private bank (all vintages)	181.4	295.9	379.0	319.0	333.4	445.3

incorrect results for the series ‘Private Bank (current vintages only)’ for the years 2013 and 2014. The numbers we incorrectly reported were 11.8 and 41.1 MMtCO₂e, respectively, when in fact the correct results are 11.9 and 43.1 MMtCO₂e. The error did not affect the underlying spreadsheet model, which remains available as supplemental information and

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Tracking banking in the Western Climate Initiative cap-and-trade program

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Keywords: climate policy, carbon pricing, cap-and-trade, overallocation, banking, California, Western Climate Initiative

Supplementary material for this article is available [online](#)

Abstract

The Western Climate Initiative is a multilateral cap-and-trade program in California and Québec. The California climate regulator has called for cap-and-trade to deliver nearly half of the emission reductions needed to achieve the state's legally binding limit on greenhouse gas emissions in 2030, making the program the single biggest driver of the state's post-2020 policy portfolio. However, the program's supply of compliance instruments has persistently exceeded emissions subject to the program—a condition known as overallocation, which independent studies have projected may continue into the mid-2020s. If market participants purchase and bank excess compliance instruments for future use, they may be able to comply with the program's regulations while nevertheless emitting significantly in excess of the state's legally binding 2030 limit. Here, we present methods for tracking observed banking behavior on both an annual and multi-year compliance period basis. By the end of 2018, market participants had already acquired more unused compliance instruments than the regulator anticipated for 2020. The size of the private bank is now comparable to the cumulative mitigation expected from the program over the period 2021 through 2030, raising questions about the program's ability to achieve its expected reductions. Beyond diagnosing market conditions, banking metrics can also help policymakers design dynamic program reforms that increase program stringency conditional on observed market behavior deviating from expectations.

1. Introduction

California's cap-and-trade program covers about 75% of statewide greenhouse gas emissions [1, 2] and, via a link to a similar program in Québec, forms the multilateral Western Climate Initiative (WCI) cap-and-trade program [3, 4]. Although the WCI is limited to just two participants today, it temporarily included Ontario in 2018 and was once intended to cover most of the Western United States, most of Canada, and parts of Mexico [5, 6].

The California Air Resources Board (CARB) is charged with implementing policies sufficient to achieve California's legally binding statewide greenhouse gas emission limits, including its cap-and-trade program. Because emissions covered under

California's cap-and-trade program are much larger than those of its current or prospective partners, policy decisions in California drive the fundamental economics of the WCI program. To date, CARB has relied primarily on a suite of ambitious direct regulations to accomplish its emission reductions, with the cap-and-trade program playing more of a supporting role [7–10]. However, CARB expects the program's role to grow as the state pursues a legal mandate to reduce statewide greenhouse gas emissions at least 40% below 1990 levels by 2030.⁵ CARB's official 2030 climate strategy calls on the cap-and-trade program to deliver 47% of the annual emission reductions necessary to achieve the 2030 limit, making the program the single

⁵ California Health & Safety Code § 38566.

largest driver of planned post-2020 reductions on both an annual and cumulative basis [11].

Well-designed cap-and-trade programs can achieve ambitious climate policy goals, but a number of independent studies have raised questions about the WCI program's ability to deliver its planned emission reductions [12–15]. Under a cap-and-trade program, regulated parties have to periodically surrender compliance instruments, defined as (1) emission allowances issued under the program and (2) a limited number of carbon offsets that credit emission reductions from outside the program. If the supply of compliance instruments is sufficiently scarce, then emissions subject to the program can be expected to fall roughly in line with program caps. If the supply of compliance instruments is generous in relation to emissions subject to the program, however, then the program may fail to constrain those emissions.

The WCI currently features a supply-demand imbalance. Every year to date, the program's supply of compliance instruments has been greater than total emissions regulated under the program (see figure 5)—a condition that, when persistent, is known as over-allocation or oversupply [15]. Overallocation conditions have weakened other cap-and-trade programs, causing low market prices that neither drive significant emission reductions nor reflect the marginal cost of reducing pollution in line with policy goals [16, 17]. Although quarterly WCI auctions to date have offered many millions of allowances for sale beyond what is needed to cover regulated parties' near-term emissions, market participants have purchased excess allowances, which they can hold or 'bank' for future use subject to certain holding limits [18]. As a result of the present supply-demand imbalance, the program's carbon price has remained low, resting at or slightly above a minimum price floor (about 15 to 18 USD/tCO₂e in recent years) [19, 20]. In contrast, official projections of post-2020 non-cap-and-trade policy costs can be an order of magnitude greater than the current carbon price [11].

A certain amount of banking is a natural and healthy component of cap-and-trade programs as firms subject to these policies may seek to reduce emissions early in order to reduce or smooth out compliance costs. However, program caps must be designed carefully if they are to deliver specific environmental performance outcomes in target years. Large banks that are capable of frustrating those goals can develop in the presence of uncertainty about future emissions or if program caps are set too high relative to emissions [16, 21, 22]. A growing literature explores how to analyze program supply-demand balance and interpret market outcomes [23–26].

Overallocation has been a prominent topic in California policy design for years. During the program's original design phase nearly a decade ago, CARB explicitly crafted its regulations with the aim of avoiding a type of overallocation problem that undermined the

first trading period of the European Union's cap-and-trade program [16, 27]. The issue returned to prominence in 2016, when demand at quarterly WCI allowance auctions collapsed due to the combination of excess compliance instrument supplies and the looming expiration of the program's legal authority at the end of 2020 [19, 28]. In 2017, Assembly Bill (AB) 398 extended California's cap-and-trade program through 2030. AB 398 eliminated uncertainty about the program's post-2020 legal authority and led to stronger demand at auction, but prices did not rise significantly above the price floor. Notably, the bill instructed CARB to '[e]valuate and address concerns related to overallocation' in the design of its post-2020 program caps.⁶

In response to this instruction, CARB's 2018 cap-and-trade rulemaking process considered a scenario in which private parties in California purchase 150 million excess California allowances by the end of 2020 and bank them for compliance purposes in the program's post-2020 period. CARB concluded that even under this scenario, its post-2020 program caps would 'conform to the statewide (greenhouse gas) reduction targets' [29]. The authors of the present study and a legislative oversight committee report criticized CARB's calculations as factually incorrect and conceptually inadequate [30, 31], but CARB concluded that overallocation concerns were speculative and therefore required no program modifications [29].

State policymakers have since called for additional reporting metrics to track observed banking behavior in order to evaluate concerns related to overallocation, as is done with other prominent cap-and-trade programs—including the northeastern US states' RGGI program [32], the European Union ETS [33], and even CARB's own Low Carbon Fuel Standard [34]. In October 2018, the Independent Emissions Market Advisory Committee (IEMAC)—an advisory body created by AB 398 that reports to both CARB and the California Legislature, on which one of us serves—concluded that current program reporting is insufficient and recommended CARB adopt metrics for tracking banking on an annual and multi-year compliance period basis [15]. CARB subsequently directed its staff to begin an informal process in 2019 to evaluate over-allocation concerns and report, by the end of 2021, on the number of excess allowances from program budget-years 2013 through 2020, inclusive [35]. In March 2019, a group of legislative leaders sent a public letter to CARB and the IEMAC that requested the development of annual and multi-year compliance period banking metrics pursuant to the IEMAC's 2018 recommendations [36]. CARB responded with its own letter in April 2019, re-asserting the conclusions of its 2018 rulemaking without addressing the issue of banking metrics [37].

⁶ California Health & Safety Code § 38562(c)(2)(D).

Here, we develop open source metrics that can be used to track compliance instrument banking in the WCI cap-and-trade program. Drawing on public program data from California and Québec, these metrics measure private and government account holdings on both an annual and multi-year compliance period basis. These metrics indicate that, as of the end of 2018, private market participants already held more unused allowances than the California regulator considered in its official evaluation of expected program conditions for 2020. The number of excess compliance instruments in Private Accounts is also comparable to the cumulative mitigation policymakers expect the program to achieve over the period 2021 through 2030.

2. Methods

2.1. Program overview

At its core, a cap-and-trade program is a legal obligation that requires regulated firms—called covered entities—to acquire compliance instruments from, and surrender these instruments to, their regulator. When a covered entity emits greenhouse gases, it incurs a compliance obligation that must be satisfied by surrendering an equal number of compliance instruments to the regulator at periodic compliance events. When a compliance instrument is surrendered to the regulator, the regulator retires the instrument—permanently removing it from circulation—and deems the associated compliance obligation satisfied.

Compliance instruments include allowances and offsets; each represents 1 tCO₂e.⁷ Program rules specify the number of allowances in each jurisdiction as well as the mechanism by which they are either freely allocated to private parties, made available for purchase at auction, or directed to various government holding and reserve accounts. In the linked WCI program, compliance instruments from each jurisdiction are recognized by the other, such that all compliance instruments are fully fungible for compliance purposes and tradable between private parties.

Each allowance originates from an individual jurisdiction with a vintage year corresponding to the program-year budget from which the allowance originally derived. For example, there are ~322 million non-reserve allowances under California's regulation for the year 2019; each of these allowances is a vintage 2019 California allowance, no matter how or when a private entity acquires it. To satisfy its compliance obligations, a covered entity may surrender any

number of allowances with vintages equal to or less than the final year of the compliance period; with some limited exceptions, it generally may not surrender later vintages for compliance purposes. Thus, in any given year and to a first approximation, only allowances with a vintage less than or equal to the calendar year of the emissions in question can be surrendered to satisfy those compliance obligations. In addition, covered entities can surrender a limited number of carbon offsets, which increase the total emissions allowed from covered entities in exchange for calculated reductions that occur outside the WCI program [15] (see figures 1 and 2).

2.2. Annual banking metrics

Annual banking metrics offer the ability to track program conditions on a regular basis, as opposed to waiting for full compliance submissions every three years.

We define the *Private Bank* of compliance instruments as the difference, calculated at the end of each calendar year, between (1) the number of eligible compliance instruments held in Private Accounts and (2) regulated firms' outstanding compliance obligations.

The intuition behind this approach is to capture only those compliance instruments held in excess of what firms already owe but have not yet surrendered to program regulators—that is, a measure of their surplus holdings at the end of every calendar year. This metric provides an annual snapshot of the supply-demand balance in the WCI program and is based on our earlier work [40], which we extend here. It is also similar to the metric used by the EU climate regulator for its cap-and-trade program [41], except that the EU metric counts all compliance instruments held by private parties, not just those that are currently eligible for compliance at the point of measurement.

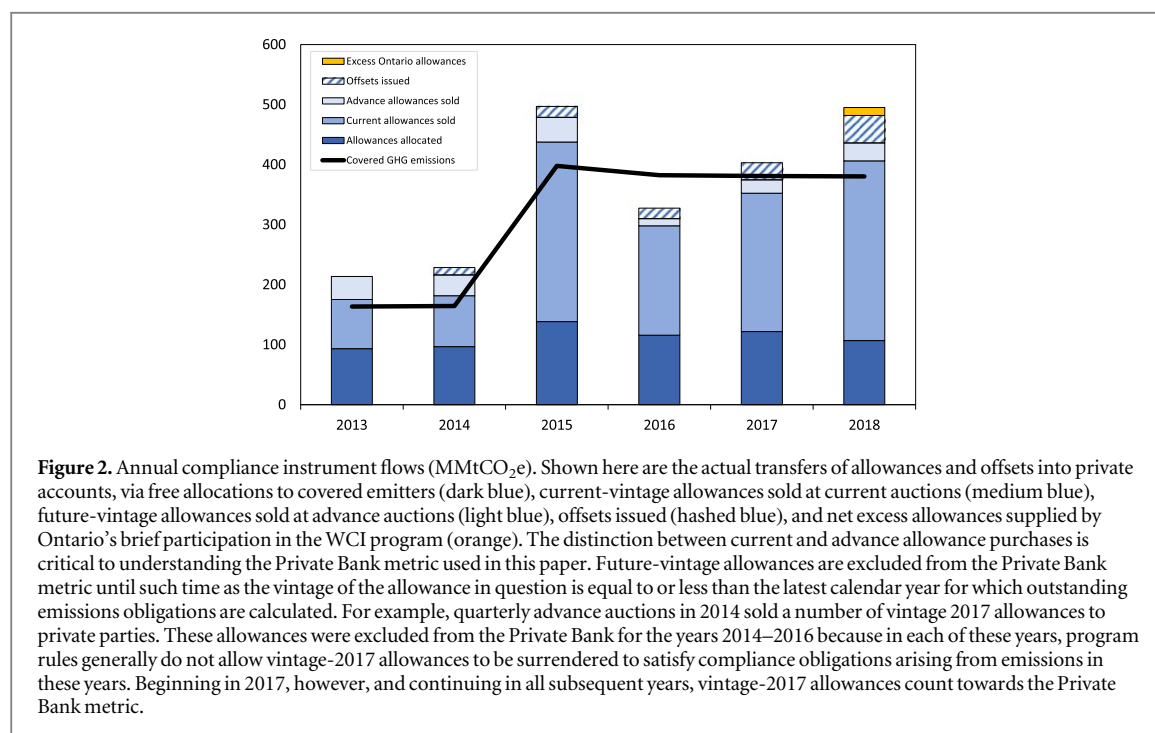
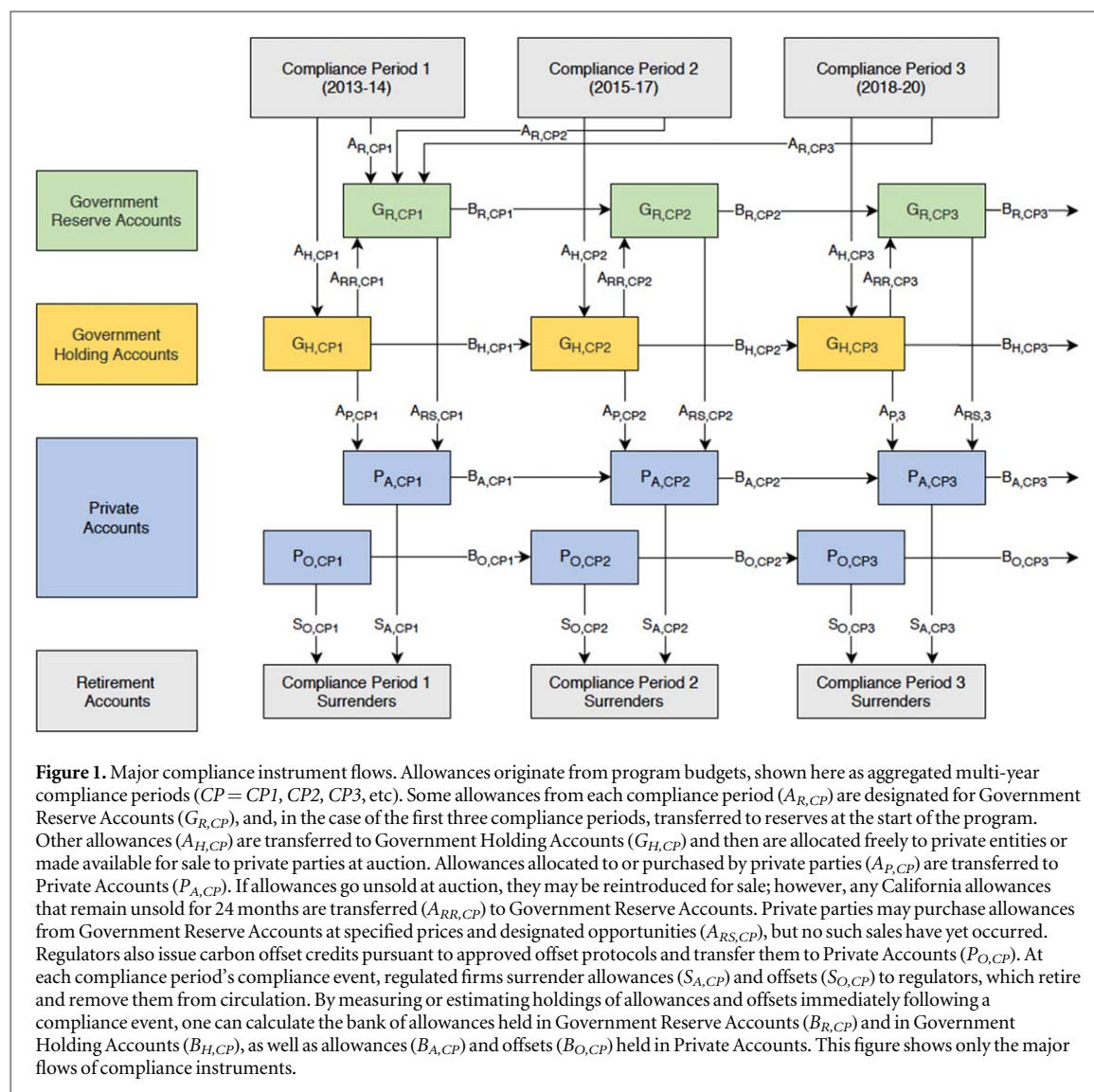
We calculate the Private Bank as follows:

$$\text{Private Bank}_t = A_{P,t} + O_{P,t} - \left(\sum_{i=2013}^t C_i - \sum_{i=2013}^t S_i \right), \quad (1)$$

where:

- $A_{P,t}$ is the number of allowances held in Private Accounts at the end of year t with vintages less than or equal to t , plus any non-vintage allowances held in Private Accounts. For example, for the 2018 Private Bank ($A_{P,2018}$) is calculated by observing the number of allowances held in Private Accounts with vintages 2013 through 2018, inclusive, along with any privately-held non-vintage allowances. Data are from quarterly Compliance Instrument Reports (CIRs), which are issued by CARB and drawn directly from CITSS, the WCI compliance instrument tracking system [42].
- $O_{P,t}$ is the number of offsets held in Private Accounts at the end of year t , drawn from the same CIRs. We

⁷ To calculate covered entities' compliance obligations in terms of tCO₂e, Québec uses 100 year global warming potential (GWPs) from the IPCC's Second Assessment Report to calculate the CO₂-equivalence of non-CO₂ gases [38]; California uses 100 year GWPs from the Second Assessment Report for emissions through 2020, and then 100 year GWPs from the Fourth Assessment Report thereafter [39].



include all offsets held in Private Accounts at the end of year t because offset credits can be banked indefinitely. This methodological choice assumes that the number of offsets held in Private Accounts does not exceed the limits imposed on their future use; historically, private offset holdings have been much smaller than such cumulative limits.

- C_i is the total compliance obligation incurred by all covered entities in the market in year i . Every November, WCI jurisdictions report covered entities' compliance obligations for the previous year. Thus, data for year t is not available until the November in year $t + 1$.
- S_i is the total number of compliance instruments surrendered to the regulator in year i , based on each jurisdiction's official compliance reports. In California, there is a compliance event every year: for each of the first two years of a three-year compliance period, a minimum of 30% of each year's obligations are due the following November; for the third year, the remaining obligations from the first two years plus 100% of the third year's obligations are due the November after the end of the third year. For example, consider emissions from California entities in 2016, a year that is in the middle of the second compliance period (2015–2017). Covered entities in California were required to satisfy at least 30% of their annual 2016 compliance obligation in November 2017, with the remainder due in November 2018 (along with the rest of their unsatisfied compliance obligations from calendar years 2015 and 2017). Québec has no annual compliance submission requirements, and instead requires that covered entities surrender 100% of their compliance obligations the November after a multi-year compliance period ends.

Because allowances and offsets can be used to satisfy compliance obligations, it is essential to include holdings of both types in the Private Bank. However, there is no objective method for determining the breakdown of excess allowances and offsets on an annual basis because private entities do not elect the final mixture of allowances and offsets they will surrender to satisfy their outstanding compliance obligations until the end of each multi-year compliance period. Although these choices cannot be observed until the end of a compliance period, they are bounded by (1) a scenario in which covered entities maximize the surrender of offsets, which results in the maximum number of banked allowances; and (2) a scenario in which covered entities surrender no offsets, which results in the minimum number of banked allowances.

The Private Bank metric can be calculated in January of year $t + 1$ as a specified quantity for years up through $t - 1$, for which all data are known, and with

an uncertainty range for year t that reflects the fact that compliance obligations in year t are not reported until November of the year $t + 1$. In turn, the previously uncertain range for year t can be resolved in November of year $t + 1$, when emissions data for year t become available.

In addition to the Private Bank, we use the same CIR data to calculate additional banking metrics that track compliance instruments held in two kinds of government accounts:

- *Government Holding Accounts* measures the number of current and historical vintage year (up to year t) allowances and offsets that are temporarily held in government-controlled accounts. Once allocated or sold at auction, these allowances are transferred to Private Accounts and will subsequently contribute to the Private Bank metric. California has an additional rule for allowances held in Government Holding Accounts: if allowances go unsold at auction and remain unsold for 24 months, they are transferred to Government Reserve Accounts, where they become available for private purchase only if market prices rise to certain specified levels [43]. As of the end of 2018, ~21 million unsold allowances had reached their 24-month limit and were transferred from Government Holding Accounts to Government Reserve Accounts; an additional ~16 million hit their 24-month limit following the February 2019 auction and were similarly transferred to Government Reserve Accounts [42]. Governments may also retire allowances from these accounts, as CARB did in 2018 to address emissions leakage in the California Independent System Operator's Energy Imbalance Market (~1.2 million by the end of 2018) [42]. In addition to allowances, Government Holding Accounts also include a small number of offsets that are temporarily held in government accounts prior to being transferred to private entities (typically < 1 million at any point in time).
- *Government Reserve Accounts* measures allowances set aside in designated government accounts, where they become available for private purchase only if market prices rise to specified levels established by regulations [43]. To date, no reserve sales have occurred. For metrics through the end of 2020, we count only the allowances that originate from program budget-years 2013 to 2020, inclusive.

2.3. Multi-year compliance period banking metrics

Multi-year compliance period metrics offer the ability to measure market conditions at the point of major program compliance events, when the actual number of allowances and offsets surrendered for compliance in that period can be observed. As a result, public data allow private and government compliance instrument holdings to be disaggregated into allowance- and

offset-specific holdings, providing a comprehensive picture of market holdings.

Calculating banking from one multi-year compliance period to the next would be trivial if WCI regulators issued a new CIR coincident with each multi-year compliance period's compliance event. Because no such CIR exists, however, we estimate what such a CIR would report by adjusting 3rd Quarter (Q3) CIR data to account for actual compliance submissions that are made about one month later; we also compare these results against information from subsequent CIR data releases, which could be used instead of the Q3 CIRs. See the supplemental information, which is available online at stacks.iop.org/ERL/14/124037/mmedia for a complete description of our data and methods. This approach is similar to the method by which the Regional Greenhouse Gas Initiative measures allowance banking at the end of its multi-year compliance periods [44].

For each multi-year compliance period, we define five banking metrics:

- *Private Allowances_{CP}* ($B_{A,CP}$ in figure 1) measures the number of allowances held in Private Accounts with a vintage less than or equal to the final calendar year of Compliance Period CP , plus any non-vintage allowances.
- *Private Offsets_{CP}* ($B_{O,CP}$ in figure 1) measures the number of offsets held in Private Accounts.
- *Government Allowances_{CP}* ($B_{H,CP}$ in figure 1) measures the number of allowances held in Government Holding Accounts with a vintage less than or equal to the final calendar year of Compliance Period CP .
- *Government Offsets_{CP}* (not shown in figure 1) measures the small number of offset credits held in Government Holding Accounts.
- *Government Reserves_{CP}* ($B_{R,CP}$ in figure 1) measures the number of allowances held in Government Reserve Accounts. For metrics through the third compliance period (CP3, 2018–2020), we count only those reserve allowances that originate from program budget-years 2013 through 2020, inclusive.

3. Results and discussion

3.1. Comparing annual banking metrics and 2020 projections

Figure 3(a) reports the results for our annual banking metrics. Notably, the bank of excess compliance instruments held in private and government accounts has generally grown over time, with the Private Bank increasing to 226.9 MMtCO₂e at the end of 2018. This is almost as much as the cumulative mitigation effort CARB expects from the cap-and-trade program over the period 2021–2030 (236 MMtCO₂e; see figure 5) [11].

Table 1 provides complete results for the annual banking metrics.

Figure 3(a) also illustrates the dynamics of the 2016–2017 WCI auction collapse. At the time, private parties had been accumulating compliance instruments in excess of near-term emissions trends, but auction sales collapsed as concerns grew about California's legal authority to operate the cap-and-trade program past its then-applicable statutory expiration at the end of 2020 [19, 28]. About 143 million state-owned allowances went unsold in quarterly auctions in 2016–2017 and were thus retained in Government Holding Accounts [43]. Under program rules, unsold state-owned allowances must be re-introduced for sale in future auctions, subject to certain limits. Private demand returned in late 2017 after the California program was re-authorized through 2030, causing auctions of current-vintage allowances to sell out—including, through the February 2019 auction, ~92 million previously unsold state-owned allowances [20]. As a result, the majority of Government Holding Account allowances eventually moved to Private Accounts.

A related pattern can be seen in the Government Reserve Accounts. There have been no reserve sales during the program's history, and therefore no significant reductions in Government Reserve Accounts. Under California regulations, however, allowances that are offered at auction but remain unsold for 24 months must be transferred from Government Holding Accountings to Government Reserve Accounts. About 37 million previously unsold California allowances to date hit their 24-month threshold [43], of which ~21 million were transferred to California's reserves prior to the Q3 2018 CIR, with the remainder transferred prior to the Q2 2019 CIR [42].

Banking metrics can also be compared against projected market conditions. Figure 3(b) compares the results of our Private Bank with projections of the number of allowances expected to be held in Private Accounts by the end of 2020 [12–14, 29]. As this figure indicates, private parties already held more allowances at the end of 2018 than CARB projected for 2020 in its recent rulemaking establishing post-2020 program caps. Actual 2018 holdings are also on track with over-allocation conditions projected by independent researchers who have identified greater concerns than CARB has acknowledged. So long as allowance auctions continue to sell out current-vintage allowances and covered emissions remain below annual compliance instrument supplies (see figure 5), the Private Bank will continue to grow.

Finally, one can also modify the annual banking metrics to include all allowance vintages, not just those that are eligible for compliance purposes at the point of measurement. For example, the EU regulator uses this broader approach to measure conditions in its carbon market [41]. Figure 5 indicates how the 'current' and broader 'all vintage' Private Bank

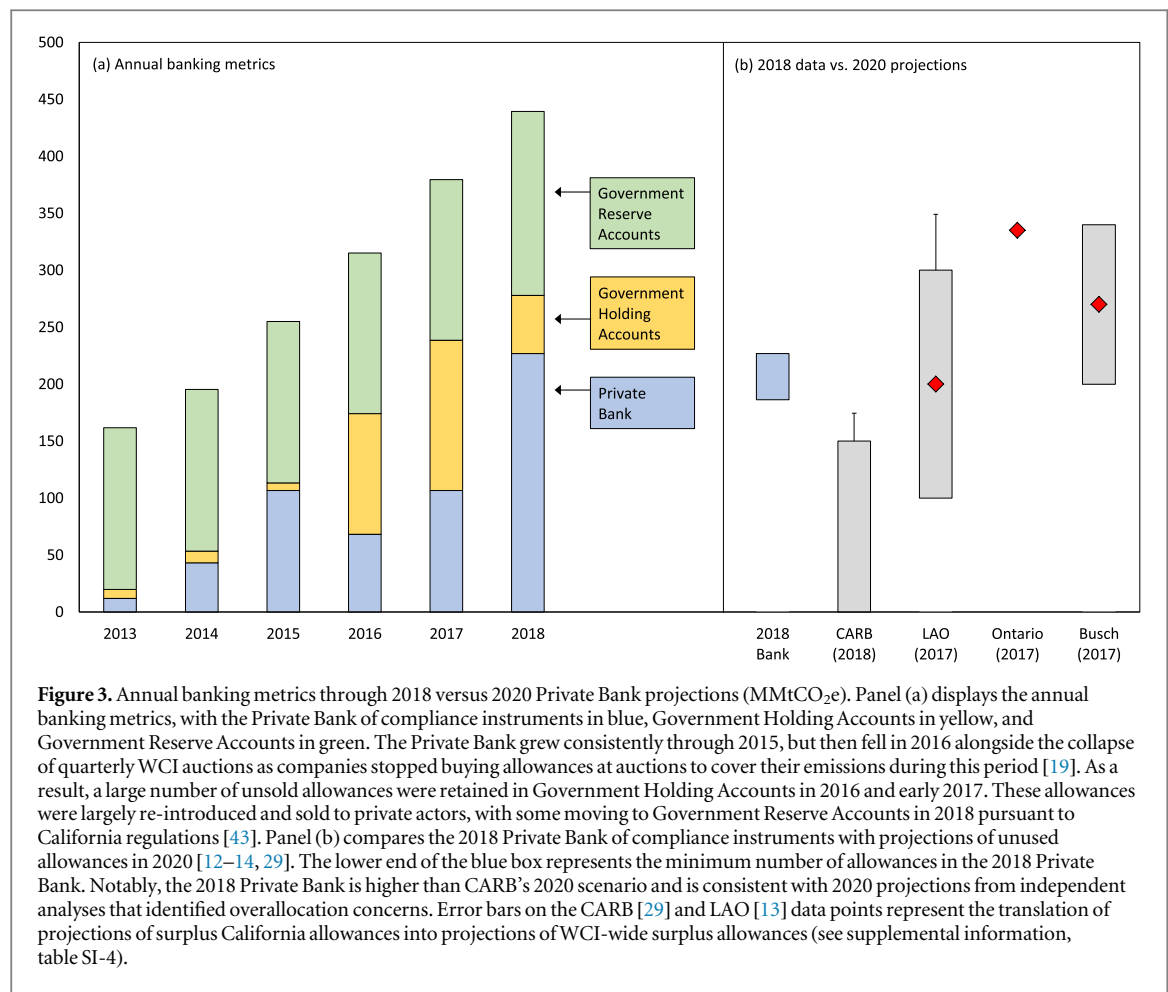


Table 1. Annual banking metric results (MMtCO₂e).

Metric	2013	2014	2015	2016	2017	2018
Private Bank (current vintages only)	11.8	41.1	106.6	68.3	106.5	226.9
Government Holding Accounts	8.0	10.4	6.6	105.9	132.1	51.0
Government Reserve Accounts	141.8	141.8	141.8	141.0	141.0	161.6
Total	161.7	195.3	255.1	315.2	379.6	439.5
Private Bank, minimum allowances (current vintages only)	11.9	32.3	89.0	41.3	59.0	186.2
Private Bank (all vintages)	181.4	295.9	379.0	319.0	333.4	445.3

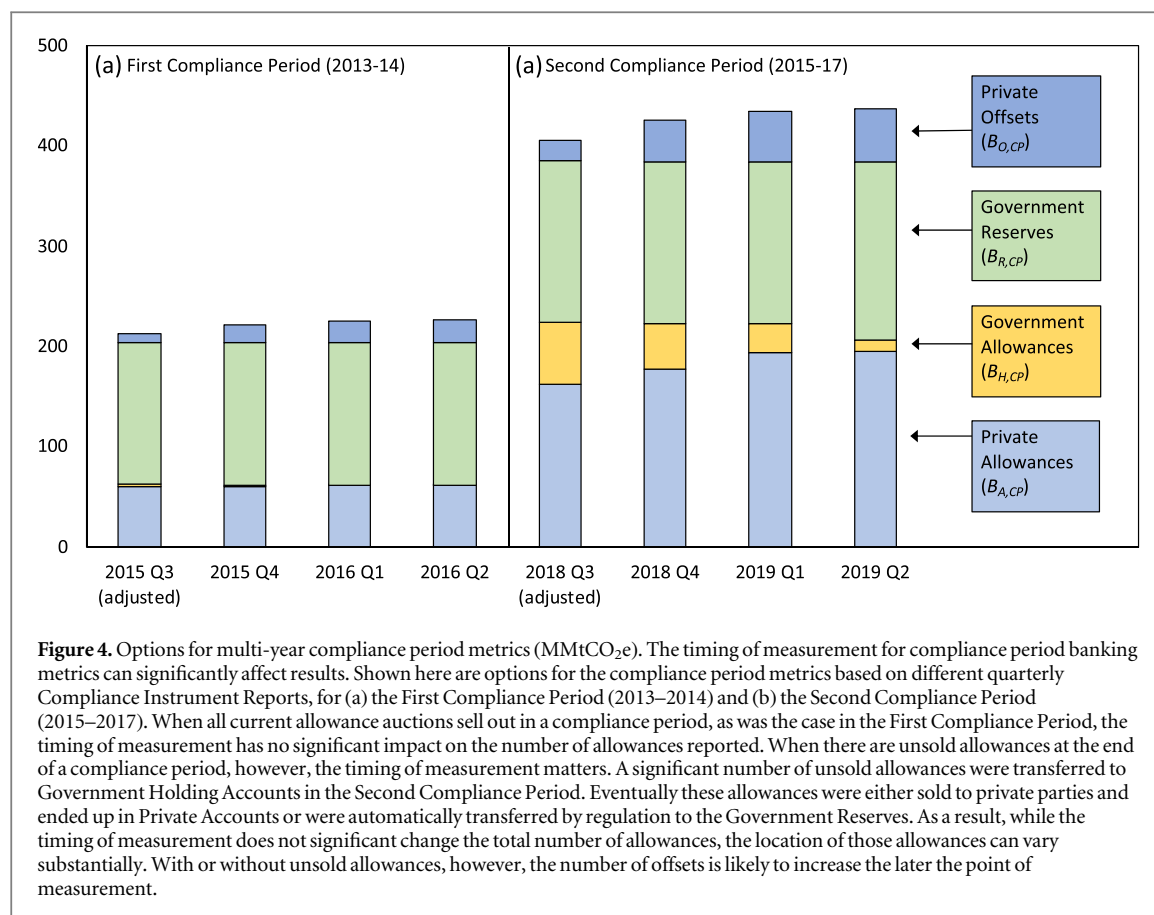
calculations compare to covered emissions and program caps. As of 2018, the ‘all vintage’ metric indicates that unused private compliance instrument holdings exceed a full year’s worth of covered emissions. While this metric provides an accurate accounting of what private entities hold as of the point of measurement, it should be interpreted carefully because it does not represent the supply-demand balance on a fully consistent calendar-year basis given the timing of allowances movements required by WCI program regulations. See supplemental information section 6 for details.

3.2. Timing of measurement for multi-year compliance period metrics

One issue policymakers may wish to consider is the timing of measurement for multi-year compliance

period banking metrics (see figure 4). Here, we develop a method based on Q3 CIRs, which are available in October each year and therefore demonstrate how CARB could deliver on its commitment to report a Third Compliance Period (2018–2020) banking metric by the end of December 2021 [35]. In order to avoid the calculations needed to use Q3 CIRs, WCI regulators could issue a new CIR immediately after each compliance event—for example, as requested by legislative policymakers in early 2019 [36].

Rather than use Q3 CIR data, however, CARB reported data concerning private holdings of unused allowances and offsets at the end of the Second Compliance Period (2015–2017) using the Q4 2018 CIR, which was published in early January 2019 [37]. If retained for reporting outcomes for the Third



Compliance Period, this approach would require a slight delay beyond what CARB promised in Board Resolution 18–51, but nevertheless would offer a straightforward methodology that has been used by market observers [45].

However, delays in reporting can change results. For example, the Q1 and Q2 2019 CIRs indicate even higher private banking outcomes for the Second Compliance Period [46] (see figure 4(b)). The primary cause of the difference between the results of these four approaches is that the Q4 2018 and Q1 2019 WCI auctions reintroduced and sold previously unsold vintage 2016 and 2017 allowances from the 2016–2017 auction collapse, with auctions occurring in between the Q3 2018, Q4 2018, and Q1 2019 CIRs. The Q2 2019 CIR shows additional changes, most notably due to ~16 M allowances having been transferred from Government Holding Accounts to Government Reserve Accounts as a result of remaining unsold for 24 months.

While the total number of banked allowances reported across private and government accounts does not change significantly from CIR to CIR, the location of those allowances varies significantly because of the presence and treatment of previously unsold allowances. If auctions are fully subscribed for two years leading up to the end of a compliance period, then the timing of multi-year banking metric measurement is unlikely to make a significant difference in reported results. Should any future auctions be

undersubscribed, however, banking metric subtotals may vary significantly depending on the timing of measurement. Table 2 provides complete results for potential multi-year compliance period banking metrics.

4. Conclusion

Questions about whether California's post-2020 program caps are sufficiently stringent are critical to resolve in light of the program's central role in the state's globally ambitious climate mitigation policy portfolio. Addressing these concerns is equally important to partner jurisdictions' policy goals, including those in Québec and in any jurisdictions that may wish to join the WCI program in the future.

Banking metrics can help resolve conflicting projections of future outcomes by tracking real-world outcomes in a consistent, empirical framework. We develop two sets of banking metrics based on official public data describing compliance instrument holdings and compliance obligations under the WCI program. One set of metrics tracks excess compliance instrument holdings on an annual basis, while the other tracks outcomes as of the compliance event following the end of each multi-year compliance period. Both sets of metrics distinguish between holdings in Private Accounts, temporary Government Holding Accounts, and Government Reserve Accounts, in order to help policymakers

Table 2. Options for multi-year compliance period banking metric results (MMtCO₂e) (Vintages 2013 through 2017 and non-Vintage Allowances only).

Series	First compliance period (2013–2014)				Second compliance period (2015–2017)			
	2015 Q3 Adjusted	2015 Q4	2016 Q1	2016 Q2	2018 Q3 Adjusted	2018 Q4	2019 Q1	2019 Q2
Date of measurement	October 2015	January 2016	April 2016	July 2016	October 2018	January 2019	April 2019	July 2019
Allowances, Private Accounts	60.9	60.5	62.1	62.1	162.6	177.9	193.9	195.5
Allowances, Government Holding Accounts	1.4	1.6	0.0	0.0	61.0	45.3	29.2	11.5
Allowances, Government Reserve Accounts	141.8	141.8	141.8	141.8	161.5	161.6	161.6	177.8
Offsets, Private Accounts	9.0	17.6	21.3	23.3	21.0	40.6	49.8	52.8
Offsets, Government Accounts	0.0	0.3	0.4	0.0	1.3	1.2	0.0	0.1
Subtotal, Allowances	204.1	204.0	203.9	203.9	385.1	384.8	384.8	384.8
Subtotal, Offsets	9.0	18.0	21.8	23.3	22.3	41.8	49.8	53.0
Total, All Compliance Instruments	213.1	221.9	225.7	227.3	407.4	426.6	434.6	437.8

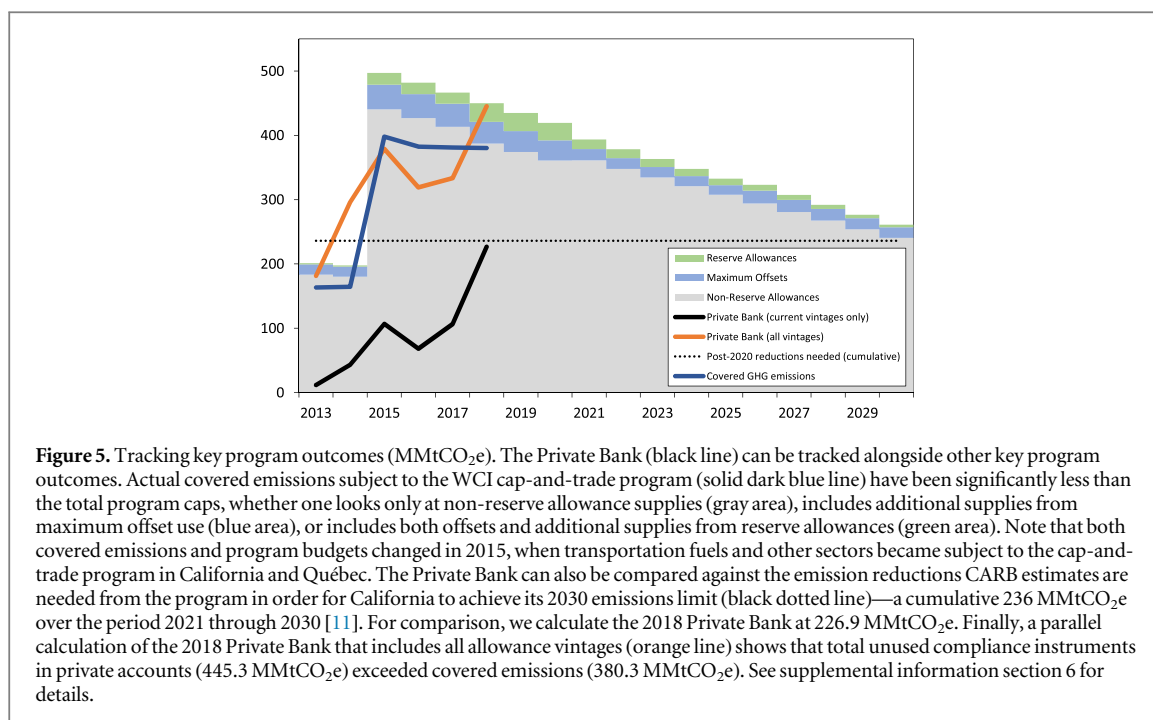


Figure 5. Tracking key program outcomes (MMtCO₂e). The Private Bank (black line) can be tracked alongside other key program outcomes. Actual covered emissions subject to the WCI cap-and-trade program (solid dark blue line) have been significantly less than the total program caps, whether one looks only at non-reserve allowance supplies (gray area), includes additional supplies from maximum offset use (blue area), or includes both offsets and additional supplies from reserve allowances (green area). Note that both covered emissions and program budgets changed in 2015, when transportation fuels and other sectors became subject to the cap-and-trade program in California and Québec. The Private Bank can also be compared against the emission reductions CARB estimates are needed from the program in order for California to achieve its 2030 emissions limit (black dotted line)—a cumulative 236 MMtCO₂e over the period 2021 through 2030 [11]. For comparison, we calculate the 2018 Private Bank at 226.9 MMtCO₂e. Finally, a parallel calculation of the 2018 Private Bank that includes all allowance vintages (orange line) shows that total unused compliance instruments in private accounts (445.3 MMtCO₂e) exceeded covered emissions (380.3 MMtCO₂e). See supplemental information section 6 for details.

and researchers observe and evaluate program-wide supply-demand dynamics.

Our results indicate that, as of the end of 2018, private parties already held more surplus allowances than CARB anticipated by the end of 2020 in its recent rule-making [29]. These results are consistent with independent projections of persistent overallocation conditions [12–14] and suggest that the issue is more significant than CARB has so far acknowledged. Furthermore, the number of excess compliance instruments in Private Accounts as of the end of 2018 is only slightly smaller than the cumulative mitigation CARB projects is needed from the program over the period 2021 through 2030 [11]. Thus, if future emissions trends follow CARB's projections of non-cap-and-trade policy impacts—and if excess instruments held by private parties at the end of 2018 are fully exhausted over the post-2020 period—then companies could potentially comply with the cap-and-trade program without significantly reducing their emissions beyond expected business-as-usual conditions.

While a full discussion of overallocation and any potential remedies is beyond the scope of this analysis, we note that policymakers have several options to achieve additional emission reductions using the cap-and-trade program. Potential reforms include reducing the future supply of compliance instruments on a one-time basis; reducing the future supply of compliance instruments using a rule-based adjustment that applies only if observed banking metrics exceed (or market prices fall short of) certain pre-determined levels, as is done for the EU ETS and RGGI programs, respectively [15, 32, 33]; and increasing the program's minimum floor price to drive additional greenhouse gas reductions in the presence of overallocation conditions.

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Data availability statement

Any data that support the findings of this study are included within the article.

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