Comments on the Outcomes and Design Issues in the 2019 Canadian Auction of Spectrum Licenses in the 600 MHz Band

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Summary

1. The recently concluded Canadian spectrum auction for the 600 MHz spectrum used the combinatorial clock auction (CCA) which included set-asides that were available only to a small number of bidders in each region.
2. While the goal of the auction was to foster competition and ensure broad availability of the 600 MHz spectrum for the upcoming 5G technology, the results fell short of this goal, and the auction ended up having a number of flaws.
3. In many regions, including the most populous one (Southern Ontario), all spectrum was acquired by just two bidders – an uncompetitive and undesirable outcome that was explicitly predicted by some of the bidders.
4. Moreover, some set-aside spectrum remained unsold even though there was excess demand from open bidders, indicating that the level of set-aside was too high, and/or eligibility to bid on set-aside spectrum was too restrictive.
5. Set-aside eligible bidders ended up paying little beyond the opening prices, again confirming the lack of competition for those licenses. The comparison of these payments to the amounts paid by set-aside ineligible bidders shows that while ISED's intention was to conduct a proper auction, the design of the auction was such that it ended up essentially giving away most of the set-aside licenses at artificially low prices to hand-picked beneficiaries.
6. The problems with the auction outcome can be traced directly to the specific features of auction design.
7. Set-asides, especially the type implemented by ISED in the 600 MHz auction (not conditional on active bidding or high prices; open to only a small number of bidders), are an inferior tool for ensuring competitive market outcomes with more than two winners. Other tools, such as caps, would have performed better.
8. The use of the combinatorial clock auction in conjunction with set-asides was also problematic. Even without set-asides, CCA has serious issues that have recently been well-documented. And given the format's complexity (relative to, e.g., the basic clock auction format used in the forward portion of the US Incentive Auction for the same spectrum bands), each additional novel feature adds a substantial risk of introducing unintended problems.

9. One specific problem that was introduced by the combination of CCA and set-asides is the complex interplay between the clock prices and allowed bids of set-aside eligible bidders and those of the remaining bidders.
10. One manifestation of this problem is the “leverage” that set-aside eligible bidders get over set-aside ineligible bidders, which allows the former to force the latter to pay high prices for the open licenses – while winning the set-aside licenses at minimal prices. This leverage could be used even when the set-aside eligible bidders have no intention of winning the open licenses, and only bid for them to drive up the prices for others, without affecting their own prices.
11. Another problem with this auction design is that clock prices can be largely disconnected from the final package prices, undermining the entire motivation behind the combinatorial clock auction design, whose essential premise (stated prominently both in the original work proposing the format and in ISED’s documents) is that the clock phase is needed to guide price discovery. As described in detail below, in the just-concluded 600 MHz auction this disconnect ended up being very large, clearly illustrating the flaws of the auction’s design.

Introduction: Auction Objectives

12. Before evaluating the outcome and discussing the design issues of the 600 MHz auction, it is helpful to summarize the policy objectives of the auction, as described in the *Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band* (ISED, 2018).
13. The key overall objective is "to maximize the economic and social benefits that Canadians derive from the use of the radio frequency spectrum."
14. As stated in the *Framework*, "ISED recognizes that Canadians want three things from their telecommunication services: high-quality services, broad coverage and affordable prices."
15. Referring specifically to the 600 MHz auction, ISED states, "[t]he deployment of the 600 MHz band will contribute to the strengthening of Canada's wireless infrastructure," and, quoting at length,
16. "Additional spectrum will allow providers to increase network capacity to meet the growing demands and support the deployment of next-generation wireless technologies. ISED views the release of the 600 MHz band as an opportunity to encourage investment and improve services. In addition, the release of this spectrum presents a key opportunity to support competition and the provision of high-quality and innovative wireless services to Canadians."
17. After stressing the critical role of the 600 MHz band in the future development and competitiveness of the Canadian economy, ISED summarizes the auction's objectives as follows: "ISED's objectives for the allocation of the 600 MHz spectrum licences are:
    - to foster innovation and investment;
    - to support sustained competition, so that consumers and businesses benefit from greater choice; and
    - to facilitate deployment and timely availability of services across the country, including rural areas."
18. As I discuss in the remainder of this document, the outcomes of the 600 MHz auction fall significantly short of achieving these objectives, and these shortcomings can be traced directly to some specific features of the design of the auction.

Evaluation of Auction Outcome

The outcome of the Canadian 600 MHz auction falls short of the policy objectives on several dimensions.

Competitiveness and Coverage

Table 1: Auction outcomes – winners and spectrum allocation

Area #	Service Area Name	A	B	C	D	E	F	G
2-001	Newfoundland and Labrador	Rogers	Rogers	Rogers	Rogers	Xplornet	Iris	–––
2-002	Nova Scotia and PEI	Rogers	Rogers	Rogers	Rogers	Xplornet	Bragg	Bragg
2-003	New Brunswick	Rogers	Rogers	Rogers	Rogers	Xplornet	Bragg	Bragg
2-004	Eastern Quebec	Rogers	Rogers	Vidéotron	Vidéotron	Vidéotron	TELUS	TELUS
2-005	Southern Quebec	Rogers	Rogers	Vidéotron	Vidéotron	Vidéotron	TELUS	TELUS
2-006	Eastern Ontario and Outaouais	Rogers	Rogers	TELUS	TELUS	Vidéotron	Freedom	Freedom
2-007	Northern Quebec	Rogers	Rogers	Rogers	Rogers	Vidéotron	Vidéotron	Vidéotron
2-008	Southern Ontario	Rogers	Rogers	Rogers	Rogers	Freedom	Freedom	Freedom
2-009	Northern Ontario	Rogers	Rogers	Rogers	Rogers	–––	TBayTel	–––
2-010	Manitoba	Rogers	Rogers	Rogers	Rogers	Xplornet	–––	–––
2-011	Saskatchewan	Rogers	Rogers	TELUS	TELUS	SaskTel	SaskTel	SaskTel
2-012	Alberta	Rogers	Rogers	TELUS	TELUS	Freedom	Freedom	Freedom
2-013	British Columbia	Rogers	Rogers	TELUS	TELUS	Freedom	Freedom	Freedom
4-170	Yukon	Rogers	Rogers	Rogers	Rogers	Iris	Iris	–––
4-171	Nunavut	Rogers	Rogers	Rogers	Rogers	Iris	Iris	–––
4-172	Northwest Territories	Rogers	Rogers	Rogers	Rogers	Iris	Iris	–––

19. The most immediate issue with the outcome, clear from Table 1, is that in many of the regions, all spectrum was won by just two providers. This is hard to reconcile with the objective of fostering competition.
20. In some cases, the resulting concentration of spectrum holdings is especially extreme: e.g., in Northern Ontario and Manitoba, Rogers ended up purchasing 80% of the spectrum sold in the auction, with the remaining 20% purchased by just one other bidder.
21. The outcome is also highly uncompetitive in the most populous area, Southern Ontario, with just two bidders winning all the 600 MHz spectrum. Such a concentrated ownership of a critical resource will damage competition and customer experience in these areas going forward. Approximately 60% of Canadian mobile subscribers[2] will end up not having full 5G coverage in Southern Ontario – a highly undesirable outcome.
22. More broadly, allowing only two bidders to split the entire 7 blocks between themselves is anti-competitive in that, to the extent 600 MHz frequency is crucial for 5G coverage over the next few years, there will be only two providers with access to it.
23. Somewhat ironically (given that Rogers ended up being the dominant winner, and the only winner of open licenses, in many markets), this outcome was explicitly predicted in the comments made by Rogers on the design of the set-asides for the auction: "A 30 MHz set-aside will likely result in a poor auction outcome since only 40 MHz will be available for the three national carriers who serve 90% of the customers. To make matters worse, there is a real likelihood that only two carriers, or perhaps just one, will win all the open spectrum. This outcome would undermine ISED's objective of four strong competitors in each region. Unless every carrier has a realistic opportunity to obtain this valuable resource, the introduction of next generation wireless services could be hindered." (Rogers Communications, 2017, "Reply Comments to Consultation on a Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band," paragraph E5).
24. As discussed further in the document, this uncompetitive outcome would not have occurred with better pro-competitive measures that could have been implemented in the auction, such as appropriately designed caps. For instance, imposing a two-license cap would have ensured at least four winners in each region, while a three-license cap would have ensured at least three.

[2] https://www.cwta.ca/wp-content/uploads/2019/05/Sub-Stats-2019-Quarter-1-EN-Web.pdf

Effective Spectrum Utilization

25. A total of eight set-aside 10-MHz blocks in six regions remained unsold. Crucially, the three national bidders (along with non-incumbent bidders active in other regions) were prevented from bidding on these unsold blocks, by the artificial (and, ex post, incorrectly determined) set-aside constraints.
26. As a result, instead of fostering competition, the presence of three-block set-asides contributed to highly concentrated outcomes in a number of regions, e.g., in Northern Ontario and Manitoba. Such outcomes will hurt consumers, in part due to the waste of a highly valuable resource (spectrum), in part due to the high concentration of the resource in the hands of just one bidder, and in part due to the small overall number of winners in these regions.
27. It is hard to reconcile these results with the Canadian government's explicit objective "to maximize the economic and social benefits that Canadians derive from the use of the radio frequency spectrum resource." Allowing all bidders to bid on these eight blocks (at least after it became clear that set-aside eligible bidders were not interested in them) would have resulted in an actual use of this valuable and scarce resource – and a more competitive situation in the relevant regions.
28. While it may be possible to reclassify these eight blocks as open, and re-auction them at a later date, the outcome will likely be quite different from what it would have been if all the blocks were sold in a single auction. The difference is due to the fact that some of the bidders who might want to assemble a package of blocks in a single-auction case will be unable to do so in the follow-up auction for just the remaining unsold blocks. Also, region by region, the winners of blocks in the main auction will have very strong incentives to also win all available blocks in the follow-up auction, to foreclose entry by others, maintaining the uncompetitive outcomes.
    a. Of course, the details of the design of the follow-up auction would also be very important for the final outcomes and the overall competitiveness in the market. E.g., simply lowering the reserve prices and re-auctioning the unsold blocks with the same set-aside eligibility restrictions will not help.

Participation and Payments by Set-aside Eligible Bidders

29. Another notable feature of the auction outcome is that none of the set-aside eligible bidders won a single open license. In effect, there were two separate auctions – one for

the open licenses, and one for the set-asides. But the set-aside bidders were allowed to bid for open licenses, distorting prices and incentives for the remaining bidders.

30. Given such a clear separation of bidders and licenses, it would have been better to simply have two separate auctions (one for open licenses, open to everyone; and one for set-asides, open only to select bidders). As I elaborate later in the document, due to the peculiarities of the CCA+set-asides combination, in the combined auction set-aside eligible bidders could artificially drive up prices for the remaining participants, at little or no risk. Being aware of this artificial feature and being concerned about this problem may have led to some open-auction participants bidding more cautiously than they otherwise would, resulting in unbalanced and uncompetitive outcomes discussed above.
31. Moreover, the difference between package prices paid for set-aside licenses vs. package prices paid for open licenses is dramatic and is hard to justify. This difference is also to a large extent due to the design of the CCA auction with 30 MHz set-asides. To illustrate the difference, it is helpful to look at how much the licenses won by the bidders would cost at opening prices, if there was no competition among the bidders for those licenses – i.e., the lowest possible prices the winners could have paid for the packages they won.

Table 2: Auction outcomes – winners' payments vs. opening prices

Winners	**# Licences Won**	**Final Price ($)**	**Total Population Covered**	**Cost at opening prices**	**Final price - opening price**
Bragg	4	$ 13,046,000	1,812,066	$ 13,046,000	0%
Freedom	11	$ 491,977,000	21,764,443	$ 423,149,000	16%
Iris	7	$ 2,556,000	633,747	$ 2,175,000	18%
Rogers	52	$ 1,725,006,000	35,150,715	$ 642,974,000	168%
SaskTel	3	$ 12,168,000	1,094,705	$ 11,823,000	3%
TBayTel	1	$ 2,802,000	778,449	$ 2,802,000	0%
TELUS	12	$ 931,238,000	19,844,765	$ 235,174,000	296%
Vidéotron	10	$ 255,780,000	10,225,169	$ 175,789,000	46%
Xplornet	4	$ 35,755,000	3,610,258	$ 12,997,000	175%

32. Table 2 presents these calculations. It augments the auction results reported by ISED with the prices of the packages that the winning bidders would have paid if they could get those packages at *opening prices* (column "Cost at opening prices").
33. Notably, some of the set-aside eligible bidders paid exactly this amount: Bragg, TBayTel, and, approximately, SaskTel (the price they paid is only 3% above the opening bid price). Thus, for these licences, the regulators shielded these bidders from *any* competition, and essentially granted the licences at the artificially low opening prices.
34. For Freedom and Iris, the differences between the opening prices and the final prices they paid are also very small – less than 20%; much less than what's typically observed in auctions for such valuable and critical spectrum as the 600 MHz band.
35. The difference is higher, but still quite moderate, for Videotron, reaching 46%.
36. Only one set-aside eligible bidder (Xplornet) paid a substantial premium over opening prices.
37. By contrast, Rogers and TELUS paid substantial premiums over opening prices: Rogers paid 2.7 times the opening prices for the licenses they won, and TELUS paid almost 4 times the opening prices.
38. Another way to illustrate the dramatic difference is to observe that Rogers and TELUS together ended up paying $2.7B for licenses whose opening prices added up to $900M, for a markup of 200%, while the remaining bidders paid slightly more than $800M for licences whose opening prices added up to $640M, for a markup of only 27% – almost an order of magnitude less. While it is of course reasonable to encourage competition and stimulate a competitive environment, such an asymmetry is extreme – and as pointed out above, in many regions such a skewed playing field likely led to a *less* balanced and competitive outcome rather than more.
39. In particular, the final package prices suggest that there was virtually no competition for most of the set-aside licenses. Essentially, by employing such generous set-asides and restricting access to them to a very small number of bidders, the government gave away an extremely valuable resource to multimillion- and multibillion-dollar companies at artificially low prices, and in many cases ended up with a less competitive outcome than what would have been achieved by an appropriately designed auction.
40. On a related note, the design of the "auction" in effect pre-determined both quantities and prices for set-aside eligible winners in many markets, thus largely eliminating all market forces from the spectrum allocation process in those cases and instead defaulting to ISED hand-picking winners and the (very low) amounts these winners should pay.

Design Issues

Set-asides

41. The issues highlighted above can be traced directly to specific problems with the design of the 600 MHz auction, and could have been avoided with alternative sets of rules. In particular, one straightforward way to ensure a competitive outcome in each region is to use caps on the number of licenses one bidder can win in each region, or more complex caps.
42. As Ausubel and Baranov (2017) say: “Spectrum caps have been prevalent in spectrum auctions worldwide. At the time of the US Broadband PCS spectrum auctions, the FCC established a 45-MHz cap for commercial mobile radio spectrum, including both existing cellular licences and the new PCS licences being auctioned. By contrast, in many of the European 3G auctions in 2000, bidders were limited to winning at most a specified number of spectrum blocks, irrespective of their existing spectrum holdings. In recent 4G auctions, bidders have often been subject to an overall constraint on existing and new holdings for spectrum generally, together with a tighter constraint on the prime sub-1-GHz spectrum. For example, in the 2013 UK 4G spectrum auction, there was both a 105-MHz overall cap on existing and new holdings (which proved to be binding for incumbent Everything Everywhere) and a 27.5-MHz cap on sub-1-GHz spectrum (which proved to be binding for incumbents Vodafone and Telefonica).”
43. Caps can be designed in many flexible ways, going beyond just the number of licenses each bidder can win in a given region. E.g., one natural design for a 7-block auction (similar to the design that was used in the recently-concluded Swiss auction) could limit each bidder to winning at most three blocks in one market, and limit any two bidders to winning at most five blocks total, if there is sufficient interest for spectrum from other bidders. Such a design would prevent valuable resources from being wasted and would ensure a more competitive outcome in every market (either four or more winners, or three winners each of whom gets at least two blocks).
44. Another possibility would have been to use “conditional set-asides”, which would “activate” only if there was sufficient interest in the licenses from set-aside eligible bidders. In fact, while the designs of set-asides look superficially similar in the Canadian 600 MHz auction and the US Incentive Auction for the same frequencies (both set aside 3 blocks out of 7), there were several crucial differences, listed below.

45. In the US auction, the set-aside provisions were only triggered once certain revenue targets were met, and set-aside eligible bidders had to be active on those licenses throughout the auction to maintain their eligibility.[3]
46. Many more bidders were eligible for reserved (i.e., set-aside) blocks in the US auction – almost all of them. In fact, even the largest bidders (AT&T and Verizon) were eligible to bid on reserved blocks in the regions where they had low amounts of comparable spectrum holdings (AT&T was eligible to bid on reserved blocks in regions corresponding to 24.9% of the US population and Verizon was eligible to bid on reserved blocks in regions corresponding to 18.5% of the population). All other bidders were eligible to bid on reserved blocks everywhere. So there was substantial competition for the reserved blocks, and their final prices ended up being within 1% on average to those of open blocks.
47. By contrast, as explained above, the Canadian design essentially gave set-aside licenses to a small number of hand-picked bidders at artificially low prices. In most regions, very few bidders were able to bid on set-aside licenses, and Rogers, Bell, and TELUS were not eligible to bid on them anywhere, even in the regions where their prior holdings of low-band spectrum were low. Under the US eligibility rules, Bell would have been eligible to bid on set-aside blocks in regions covering approximately 25% of the Canadian population, and TELUS would have been eligible to bid on set-aside blocks in regions covering 75% of the population. So, while the design of set-aside eligibility looks superficially similar in the US and the Canadian auctions, the actual implementations were critically different, resulting in much more competition in the US.
48. Overall, unlike the Canadian 600 MHz spectrum auction, the US Incentive Auction that allocated the same frequencies was able to stimulate participation by a diverse set of bidders without giving away the licenses at low pre-determined prices and without essentially mandating the outcomes in any regions.
49. One of the features that contributed to such pre-determined outcomes at artificially low prices (as well as the concentrated holdings) was the highly unusual restriction that set-aside blocks in a given region were only available to *regional incumbents already active in that region* (in the wireless or wireline markets). This feature is anticompetitive,

[3] As Ausubel, Aperjis, and Baranov (2017) explain: "The solution the FCC adopted is the conditional reserve, according to which spectrum is set aside only when the net revenue condition from the stopping criterion is met. Moreover, the number of licenses to be set aside would be the smaller of a pre-determined number or the number of licenses being demanded by qualified bidders at the time the criterion is satisfied. In that way, the set aside would not threaten clearing, but would be effective at encouraging competition once the clearing condition had been met."

both within the context of the auction itself, and from the point of view of subsequent market structure. From the point of view of the auction, this feature resulted in a very low number of bidders eligible to bid for set-aside blocks in many regions, all but guaranteeing low competition and very low prices for these blocks (which is exactly what happened in the auction). In the context of subsequent market structure, this feature essentially segments the regional markets among different providers and makes it difficult for one regional provider to enter another, new market. Segmenting the markets, and not competing on each other's turf, is a canonical anticompetitive measure employed by oligopolists in many industries – but typically regulators try to prevent such behavior and find ways to disrupt it, instead of facilitating and encouraging it, as the 600 MHz auction inadvertently did. While the goals of the regulator were to foster competition, the actual implementation of the auction in many cases ended up with the opposite results.

50. Another significant problem with allocating set-aside blocks to regional incumbents is that it forces ISED to decide what it means to be "active" in a particular market. Given the complexities of the industry and the lack of clear boundaries between many complementary and synergistic products and services,[4] any such decision is virtually guaranteed to result in quite arbitrary rules and sets of eligibilities. For example, in the 600 MHz auction, Freedom Mobile ended up being eligible to bid in *all* regions, while other regional providers were much more restricted. In effect, in addition to keeping three blocks of spectrum per region away from Rogers, Bell, and TELUS, ISED skewed the playing field in some other, fairly arbitrary directions, creating the impression of favoritism. Instead of pre-determining winners and favorites, It would have been much more natural and objective to either determine set-aside eligibility region-by-region based on existing spectrum holdings, or to simply allow all bidders (except for Rogers, Bell, and TELUS) to bid on set-aside blocks in all regions, and rely on build-out requirements and resale limits to ensure that those bidders are serious. An even more direct way to ensure subsequent competition in the industry would have been to use caps instead of set-asides.

CCA vs. Other Formats

51. The problems with set-asides were exacerbated by their combination with the combinatorial clock auction format (CCA).
52. Unlike some other, more robust and transparent designs (e.g., the basic clock auction employed in the US Incentive Auction for the same spectrum band), the CCA is very

[4] Is cellular service related to wireline internet? Cable TV? Satellite TV? Radio? Music? Home security services? Internet streaming services?

complex, and has many moving parts, activity and revealed preference rules, clock and supplementary rounds, etc., all of which are interdependent and need to be carefully coordinated. This combination of features makes CCA very fragile and very sensitive to the addition of new features.

53. As Ausubel and Baranov (2017) say, "[T]he CCA becomes more sensitive when adding novel instruments – and it is also easy for the well-intentioned regulator to introduce inadvertent design flaws into the process."
54. Before proceeding to the specific issues with the CCA and set-asides, it is helpful to review the shortcomings of the basic CCA format, even in the absence of set-asides, as discussed in Levin and Skrzypacz (2016), Janssen and Kasberger (forthcoming), and a number of other academic papers.
55. The original motivation behind the CCA format, as expressed by Ausubel, Cramton, and Milgrom (2006) in the paper introducing this format, is as follows. If it were easy for the bidders to evaluate all possible packages of items, and submit the bids on all the possible combinations, the auctioneer could simply conduct a one-shot single-bid auction (say, VCG or a bidder-optimal core-selecting proxy auction) that has desirable efficiency and incentive properties. However, even with a moderate number of licenses, evaluating all possible combinations becomes prohibitively expensive for the bidders. Thus, the clock phase is intended to help with "price discovery", helping bidders get an idea of what the final prices might be, and thus helping them decide which packages to evaluate in detail (for subsequent bidding in the final, single-shot phase). Below are some key quotes from Ausubel, Cramton, and Milgrom (2006) explaining this intuition and motivation:
    a. "The clock-proxy auction begins with a clock auction for price discovery and concludes with the proxy auction to promote efficiency."
    b. "The clock phase provides price discovery that bidders can use to guide their calculations in the complex package auction."
    c. "Like the clock auction, the proxy auction is based on package bids. However, the incentives are quite different. [...] the proxy phase is not about price discovery. It is about providing the incentives for efficient assignment. All the price discovery occurs in the clock phase."
56. Unfortunately, as researchers and practitioners have gained experience with CCA, it became clear that the reality is very different, and the format does not possess these properties even in the most straightforward and basic cases. For instance, as Levin and Skrzypacz explain, in a very simple case with just one type of license for sale (with multiple licenses of that type) and other reasonable assumptions, instead of providing

preliminary price discovery, the clock phase instead fully pins down the allocation of licenses among bidders, and the only role that's left for the final phase is determining the prices paid by the bidders – *precisely the reverse of the stated original motivation behind the design of the CCA format*.

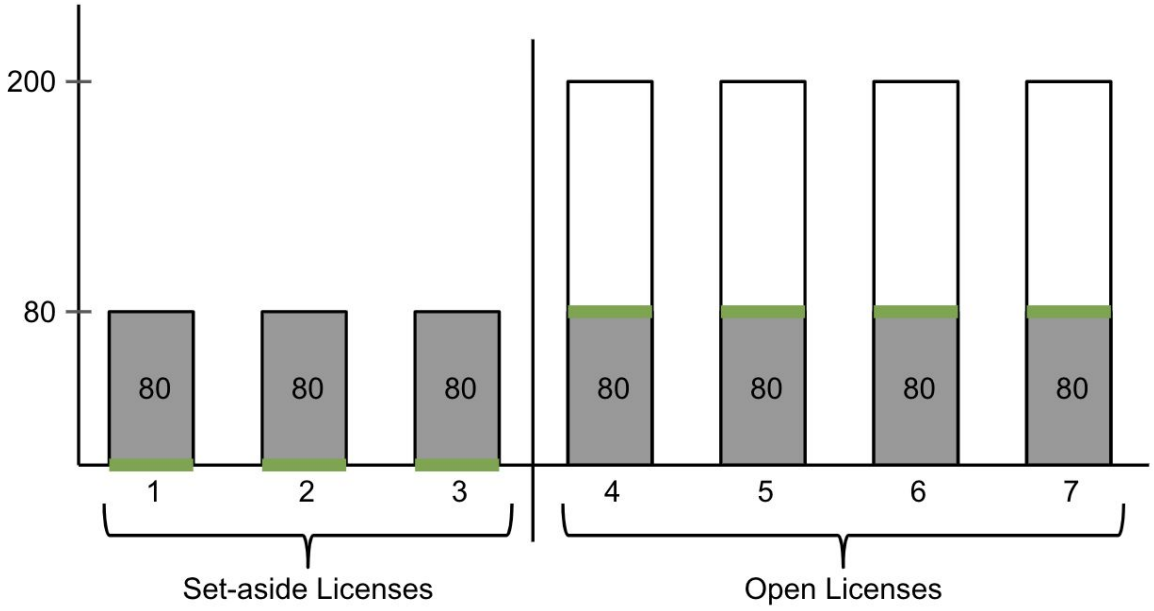
57. Moreover, the clock phase creates various possibilities for strategic behavior by the bidders, which can affect the final allocations and the payments made by other bidders. E.g., Section III of Levin and Skrzypacz discusses the incentives for bidders to engage in *predatory behavior*, when during the clock phase, they artificially inflate their demands, thereby driving up other bidders' costs – which, in turn, prompts those other bidders to "engage in demand reduction, leading to an inefficient outcome where the predatory bidder obtains an advantage."
58. To quote extensively from the conclusions of Levin and Skrzypacz (2016):
    a. "The [CCA] provides bidders with the opportunity to raise rival prices with little or no risk to their own payoff by relaxing the constraints on their final bids. We have illustrated how this can lead not just to higher payments, but to distorted incentives in the clock phase and inefficient allocations. In Section III, a single predatory bidder maintains high demand during the clock phase before dropping demand to clear the market, leading to an equilibrium[5] in which the second bidder reduces demand to avoid high payments.
    b. "A loose way to summarize these points is that in order to support a truthful equilibrium as we expect in a Vickrey auction[6], the CCA relies on bidders behaving "just right": raising their final round bids maximally so that the revealed preference activity constraints bind, but not taking actions in the clock phase to purposely relax these constraints. Our examples show how, if bidders are not sufficiently aggressive, or are overly aggressive, incentives for demand expansion and/or reduction appear and outcomes need not be efficient [...]"
59. As Levin and Skrzypacz show, these issues arise even in the most basic version of CCA, even with just one type of license for sale and very simple bidder preferences. Unfortunately, things get even worse in the case of CCA with set-asides, at least in the design implemented in the 600 MHz auction.
60. To illustrate, consider the following example, deliberately simplified to make the issues as transparent as possible. Suppose there is only one region, three set-aside licenses, four open licenses, opening prices are zero, and there are two bidders: one set-aside eligible

[5] i.e., a combination of bidder strategies that are optimal for each bidder given the behavior of others.
[6] i.e., a generalization of the second-price auction in which winners pay opportunity costs.

bidder (A), and one not eligible (B). Bidder A's value per license is $80M, and Bidder B's value per license is $200M.

61. Consider first an alternative design in which set-aside licenses are sold first, in a separate auction (or even simply given away), and the open licenses are then sold in a subsequent auction. Bidder A would then get three licenses at the opening prices (i.e., free), and in the second auction, under straightforward bidding, Bidder B would end up winning 4 licenses and paying their true economic value for Bidder A: $320M (i.e., $80M per license). See Figure 1 for an illustration.

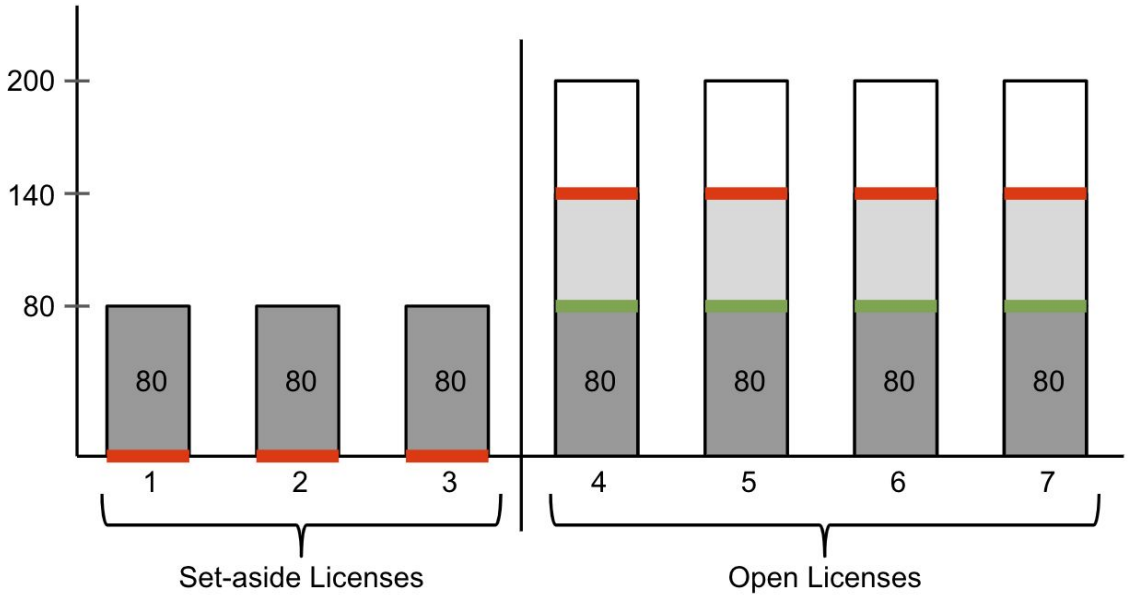
    Figure 1:



62. Consider now what would happen in the current design, under straightforward bidding in the clock phase. As long as the clock price per license is under $80M, both bidders continue to demand the highest available quantity (7 licenses for Bidder A, 4 licenses for Bidder B). Note that because the demand for set-aside licenses exceeds 3, the clock price for open licenses and the clock price for set-aside licenses are the same (thus we can talk about "the clock price per license").
63. Above $80M, the set-aside eligible bidder drops out, and the clock phase ends.
64. Suppose now that in the final phase, Bidder B submits its true value ($200M per license, for every package up to 4 licenses), while Bidder A, knowing that it cannot win any open licenses anyway, submits a minimal bid just on the 3 set-aside licenses (note that the activity rules allow the bidder to do that).

65. As a result, Bidder A gets 3 licenses at the opening prices (zero), which is the same amount it would pay in the alternative design.
66. By contrast, Bidder B will pay $560M for the licenses that it won, i.e., $140M per license – substantially higher than the true opportunity cost of those licenses (i.e., their value to the other bidders – only $80M per license). The reason for this much higher per-license price is that in essence, the pricing rule used in the auction assumes that by winning the four open licenses, Bidder B takes away the value of the entire seven-license package from Bidder A. Since Bidder A's value for this package (as expressed in the clock phase of the auction) is equal to 7×$80M = $560M, that's the amount the auction charges to Bidder B – for whom it translates into $140M per license. See Figure 2 for an illustration.

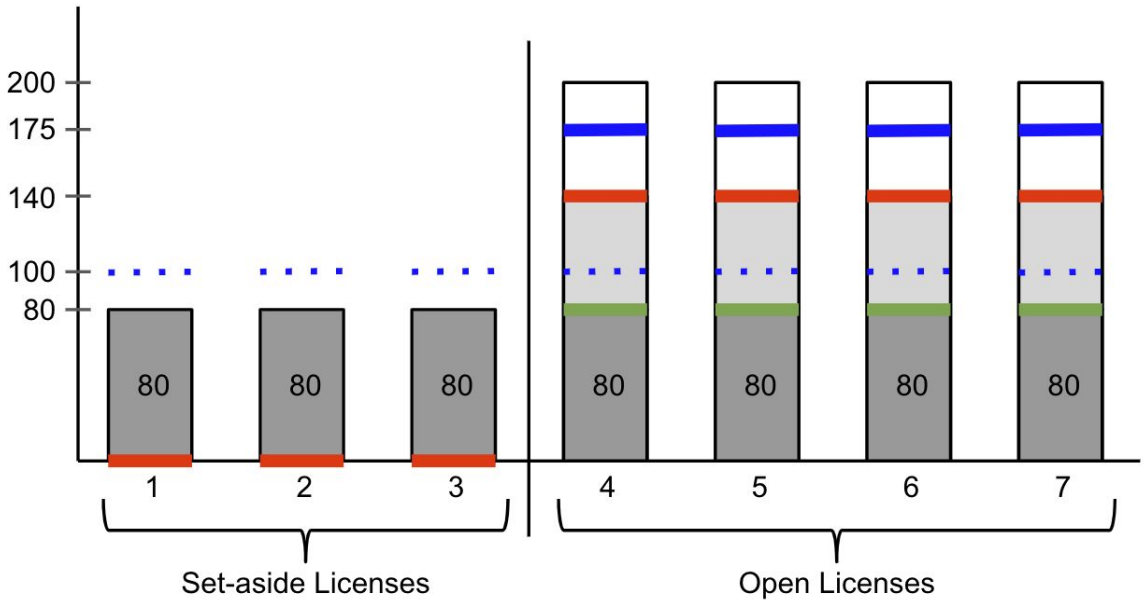
Figure 2:



67. Thus, the current CCA + set-asides design not only substantially advantages setaside-eligible bidders by giving away licenses to them at extremely low prices (as documented above), but also has the potential to substantially (and unreasonably) penalize the remaining bidders, by charging them much more than the actual opportunity cost of those licenses.
68. The asymmetry gets even worse if Bidder A is more strategic, has an estimate of Bidder B's valuation, and would like to force Bidder A to pay a high price (see the paper by Janssen and Kasberger for an extensive discussion of various reasons for bidders to try to raise rivals' costs, and subsequent problems and inefficiencies arising in CCAs because of these reasons). Then Bidder A can stay in the clock phase of the auction slightly longer

than what its valuation suggests and can raise Bidder B's costs even higher. E.g., in the above example, if Bidder A stays in the clock phase (and continues bidding for all seven blocks) until the clock price gets to $100M per block, it can force Bidder B to pay $700M for the four blocks that Bidder B will win, or $175M per block. Meanwhile, Bidder A continues to pay just the opening price (zero in this example) for the three licenses that it wins. See Figure 3 for an illustration.

Figure 3:



69. Of course, a similar issue arises even in a simple auction with no set-aside, if one bidder knows that a rival's valuation is higher and tries to force that rival to pay as much as possible. However, in a regular auction, in order to force a rival to pay $175M per block, a bidder would need to stay active until the clock price gets to that number ($175M), and risk paying that amount per block if the rival unexpectedly withdraws. By contrast, the CCA + set-asides design of the 600 MHz auction gives the set-aside eligible bidder very powerful (and probably unintended) leverage: such a bidder can force its rival to pay $175M per block while the bidder itself only risks paying $100M per block. Moreover, the problem is highly asymmetric: there is no way for the non-set-aside eligible bidder to affect the prices paid for set-aside licenses; a set-aside eligible bidder enjoys getting those licenses at minimal prices, and on top of that can use the leverage described above to force an open bidder to pay a high price for the open licenses. This, in turn, may lead the open bidder to bid more conservatively, resulting in an inefficient allocation.

70. Another major problem, both in the example above and more generally, is that clock prices lose their informativeness. In the *Framework* document, ISED echoes the original CCA proposals in explaining the role of the clock phase of the auction: “The clock rounds allow for price discovery, helping to reduce a bidder’s uncertainty regarding the value of the licenses. Bidders are able to respond to these price changes accordingly, shifting their bids to licenses that continue to be consistent with their business objectives.”
71. However, it is easy to see that in the above examples, the clock price becomes completely decoupled from the final prices paid by the bidders. E.g., in the first example, the clock price stops at $80M per block. However, neither bidder pays anything close to this amount: the set-aside eligible Bidder A pays zero per block, while the ineligible Bidder B pays $140M per block. Given this disconnect, created by adding set-asides to a CCA, the value of the clock phase (which is supposed to provide reliable price guidance and help with price discovery) becomes questionable, undermining the entire premise behind CCA.

Examples from the 600 MHz Auction

72. The above examples illustrate some theoretical problems with the CCA in combination with set-asides as implemented in the 600 MHz auction. Unfortunately, the shortcomings of the auction design manifested themselves in the actual bidder behavior and auction outcomes and prices.
73. The combination of CCA and set-asides implemented in the 600 MHz auction indeed allowed some bidders to behave in a highly strategic manner that was unlikely to reflect those bidders’ true valuations for the licenses. Of course, all spectrum auction formats are complex and induce some degree of strategizing, but typically, in a well-designed auction, the companies’ bids during the clock phase reflect their true economic interests at least to some extent, ensuring that prices are informative and reflective of the true value of the licenses. By contrast, the design of the 600 MHz auction led some bidders to behave in a very different, non-monotonic and almost chaotic-looking manner. E.g., during the course of the auction, Freedom Mobile (which, unlike most other bidders, was set-aside eligible in all regions) ended up submitting bids of 7 blocks (i.e., all available spectrum) in all but one region. Tellingly, their bids in the first two rounds of the clock phase look consistent with their true economic interests and are similar in footprint to the package they eventually

won.[7] But during the clock phase, the packages they bid on looked very different. For instance, in round 6, Freedom Mobile bid on 6 or 7 blocks in all but three Canadian regions, and bid on zero blocks on the remaining three (with one of the remaining three being Southern Ontario – one of their key regions). In many of the subsequent rounds, Freedom continued bidding on six or seven blocks in many regions, constantly shifting around the footprints of those bids. See Table 3 for an example: Freedom's package bid in the opening round, in rounds 6 and 11, and the final package that they won. Such behavior is hard to reconcile with true valuations for spectrum packages and is much more likely to reflect highly strategic behavior. I want to emphasize that I am not implying that Freedom Mobile or any other bidders did anything that they were not supposed to – rather, they are simply responding to the incentives created by the design of the auction and the allocation of set-aside eligibility.

Table 3: Bidding patterns by Freedom Mobile in select rounds, and their final package

Area #	Area Name	Round 1	Round 6	Round 11	Final
2-001	Newfoundland			7	
2-002	Nova Scotia		7	7	
2-003	New Brunswick		7	7	
2-004	Eastern Quebec		7		
2-005	Southern Quebec		7	3	
2-006	Eastern Ontario	7	7	7	2
2-007	Northern Quebec			7	
2-008	Southern Ontario	6		3	3
2-009	Northern Ontario		7	7	
2-010	Manitoba	3	7	3	
2-011	Saskatchewan		7	7	
2-012	Alberta	6	7	5	3
2-013	British Columbia	6	6	7	3
4-170	Yukon		7		
4-171	Nunavut		7		
4-172	Northwest Territories		6		

[7] In the opening round of the auction, Freedom Mobile bid on licenses in Alberta, British Columbia, Manitoba, and Eastern and Southern Ontario. It ended up winning licenses in Alberta, British Columbia, and Eastern and Southern Ontario.

74. Similarly, the opening bid by Videotron is consistent with the package they ultimately won, and both the opening bid and the final package are easy to explain based on Videotron's likely fundamental economic valuations, given their business activities. By contrast, and analogously to Freedom's behavior, the bids in intermediate rounds appear much less "sincere," with Videotron, at various points, bidding on the maximum number of licenses allowed (4 for open regions, 7 for set-aside) in all but two regions (in which they also bid for a substantial number of licences: 5 in Southern Ontario and 2 in Northwest Territories). Two rounds of such bids by Videotron (rounds 16 and 21), along with the opening bid and the final package, are shown in Table 4.

Table 4: Bidding patterns by Videotron in select rounds, and their final package

Area #	Area Name	Round 1	Round 16	Round 21	Final
2-001	Newfoundland		4	1	
2-002	Nova Scotia		4		
2-003	New Brunswick		4		
2-004	Eastern Quebec	7	3	3	3
2-005	Southern Quebec	7	3	3	3
2-006	Eastern Ontario	7	3		1
2-007	Northern Quebec	7	3	3	3
2-008	Southern Ontario	4			
2-009	Northern Ontario		3		
2-010	Manitoba		2	3	
2-011	Saskatchewan		4	4	
2-012	Alberta	1	4	4	
2-013	British Columbia	1	4	4	
4-170	Yukon			4	
4-171	Nunavut			4	
4-172	Northwest Territories			2	

75. The format of the 600 MHz auction is particularly conducive to such strategic and non-value-based bidding behavior, relative to, e.g., a basic clock auction format (like the one proposed for the 3500 MHz auction) or a SMRA (simultaneous multi-round auction). The reason is that under the 600 MHz auction format, it was riskless to bid on packages

that the bidder had no chance of winning. E.g., Freedom's bid in round 6 (and in many others) could only win if the remaining bidders were willing to walk away from *all* licenses in 11 out 16 regions. This is essentially a zero-probability event that was not going to happen. Knowing that, it was completely safe for Freedom to submit such a bid, with no risk of actually winning it. The benefit of submitting such a bid is that it allows Freedom to "park" activity points for future deployment in regions that they actually want to win (e.g., Southern Ontario, in which they were clearly interested and in which they ended up winning three licenses, but on which they submitted no bid in round 6), without affecting the clock prices in that region. So Freedom's claimed demand in round 6, in many of the regions, is completely fictitious and only serves strategic purposes. However, the clock phase of the auction treats these demands as "real," increasing clock prices in regions with excess perceived demand (even when there is no "real" excess demand). As a result, it is not surprising that there was such a dramatic disconnect between the final clock prices in the auction and the actual prices that many of the bidders ended up paying (see below for details).

76. Of course, the strategy of "parking" points can also be used in the basic clock auction (CA) or SMRA, but in those auctions, such a strategy is much riskier, because a bidder could easily get "stuck" in some of the regions if others reduced their demands below supply there. For instance, as discussed above, eight 10-MHz blocks (in Newfoundland, Northern Ontario, Manitoba, Yukon, Nunavut, and Northwest Territories) remained unsold in the 600 MHz auction. Under Freedom's bids in rounds 6 and 11, or Videotron's bids in rounds 16 and 21, this could not have happened in a basic clock auction – Freedom or Videotron would have been "stuck" with them and would end up winning them. This possibility of getting "stuck" substantially disciplines bidders' parking (and other strategic) behavior, bringing bidding closer to being value-based.
77. A closely related point is that in CA and SMRA, *clock prices are real*, and have a bite. If a bidder bids on a license with a clock price of $1 million, and wins it (i.e., others withdraw), it will pay that $1 million. So clock prices genuinely guide allocations and discipline bidders' strategizing. By contrast, in the 600 MHz auction format, it was completely safe for bidders to submit insincere package bids that they knew had no chance of winning, completely disregarding (but at the same time affecting!) clock prices.
78. As a result, it is not surprising that the final clock prices in the 600 MHz auction in many cases ended up being completely disconnected from the actual final prices. Table 4 presents the summary of auction winners, with the opening prices, the amounts the winners would have had to pay under clock prices in the final clock round, and the

amounts they in fact ended up paying (which include payments for specific frequencies in the assignment phase).

Table 4: Auction outcomes – winners' payments vs. opening prices and clock prices

Winners	Licences Won	Total Population Covered	Cost at opening prices ($)	Cost at final clock prices ($)	Final price ($)	Final price paid/ Final clock price
Bragg	4	1,812,066	$ 13,046,000	$ 51,252,000	$ 13,046,000	25%
Freedom	11	21,764,443	$ 423,149,000	$ 852,157,000	$ 491,977,000	58%
Iris	7	633,747	$ 2,175,000	$ 6,351,000	$ 2,556,000	40%
Rogers	52	35,150,715	$ 642,974,000	$ 2,693,514,000	$ 1,725,006,000	64%
SaskTel	3	1,094,705	$ 11,823,000	$ 53,760,000	$ 12,168,000	23%
TBayTel	1	778,449	$ 2,802,000	$ 8,625,000	$ 2,802,000	32%
TELUS	12	19,844,765	$ 235,174,000	$ 1,168,670,000	$ 931,238,000	80%
Vidéotron	10	10,225,169	$ 175,789,000	$ 368,543,000	$ 255,780,000	69%
Xplornet	4	3,610,258	$ 12,997,000	$ 47,243,000	$ 35,755,000	76%

79. It is clear from Table 4 that for many bidders, there is essentially no connection between clock phase prices and the final prices they paid – instead, the latter are determined by the opening prices. For Bragg and SaskTel, final clock prices are approximately four times as high as the actual amounts they ended up paying. For Iris and TBayTel, they were higher by factors of 2.5 and 3. For all other bidders, the clock prices were also significantly higher than the final prices. It is hard to reconcile such dramatic differences between clock and final prices with ISED's stated justification for the clock phase, that "[t]he clock rounds allow for price discovery, helping to reduce a bidder's uncertainty regarding the value of the licenses."

Looking Ahead: The 3500 MHz and Other Future Auctions

80. ISED (2019) has recently released the consultation on the rules of the upcoming 3500 MHz spectrum auction.
81. The consultation proposes the elimination of the CCA format and proposes replacing it with the basic clock auction format with generic licenses (CA). This is a major improvement, fixing some of the major issues in the design of the 600 MHz auction. In particular, bidders will not be able to submit completely insincere package bids, knowing that they have no chance of winning those packages and thus facing no risk when bidding on regions that they have no interest in actually winning. Relatedly, prices in the proposed clock auction format will be "real," and genuinely reflect the amounts bidders will ultimately have to pay, indeed allowing for actual price discovery – unlike in the 600 MHz format. The risk of unallocated blocks also appears to be lower.
82. However, it is also important to properly address the remaining issues: caps and set-asides (and in the case of the latter, the rules governing set-aside eligibility).
83. As the 600 MHz auction made clear, set-asides are not the right tool to ensure that the final auction outcomes result in a competitive allocation of spectrum, and instead, in many cases, push the industry closer to duopoly (with one bidder winning all open blocks, one bidder winning all or some set-aside blocks, and nobody else winning anything else).
84. The problem may be even more severe in the 3500 MHz auction, where some bidders already have substantial spectrum holdings in the band (and thus may have especially strong incentives to monopolize the region and prevent other bidders' entry) and individual regions are smaller (which makes it potentially easier and cheaper to prevent new entry, by acquiring all available licenses in small but critically important regions).
85. The determination of set-aside eligibility in the 3500 MHz auction is also complicated by the highly non-uniform current spectrum holdings in various regions. As discussed above in the document, even without existing holdings, determining the appropriate amount of set-aside spectrum and the eligibility rules is a very challenging problem that is hard to solve without unintentionally tilting the playing field in favor of some auction participants. In the presence of existing holdings by various providers, the problem becomes even more challenging.
86. In such circumstances, carefully designed spectrum caps (which take into account both existing holdings and spectrum acquired during the auction) are a natural tool to ensure

the competitiveness of the post-auction industry, without hand-picking the winners or inadvertently favoring some bidders over others.

87. If ISED does decide to include set-asides as part of the design of the 3500 MHz auction, they should think carefully about the interaction between those set-asides and the existing holdings of various bidders. Beyond that, they should allow all set-aside eligible bidders to bid on all set-aside blocks, instead of pre-determining who is eligible to bid where, based on highly imperfect criteria and hard-to-determine industry boundaries. Build-out requirements and resale limits are a much simpler and more straightforward tool for ensuring serious bidding on those set-aside blocks, without tilting the playing field and creating artificial asymmetries among set-aside eligible bidders and unintentionally favoring some of them over others.

Concluding Remarks

88. The outcome of the 600 MHz auction fell short of ISED's goal in many regions, including some very populous ones. These shortcomings can be traced to specific features of the auction rules employed by ISED.
89. Examples show that the use of the combinatorial clock auction in conjunction with set-asides is potentially highly problematic. Set-aside eligible bidders were demonstrated to have "leverage" over set-aside ineligible bidders, allowing the former to force the latter to pay high prices for the open licenses, while winning the set-aside licenses at minimal prices. Furthermore, the potential was illustrated for clock prices to end up being largely disconnected from the final clock round's package prices, undermining the motivation behind the combinatorial clock auction design, whose essential premise (stated prominently both in the original work proposing the format and in ISED's documents) is that the clock phase is needed to guide price discovery.
90. In the 600 MHz auction, some of the bidders engaged in highly strategic behavior that in many rounds of the clock phase likely did not reflect their true valuations for spectrum, and instead exploited shortcomings of the auction design, undermining the rationale for the clock phase.
91. Also undermining the rationale behind the combinatorial clock auction design, prices in the clock phase ended up being largely disconnected from the final package prices, in many cases being off by a factor of 3–4 or even more.
92. Many alternative auction features and designs (including much simpler and more robust overall designs like a standard CCA or a basic clock auction with more direct pro-competitive features like caps) are available and have been used in many important markets. As ISED is getting ready to conduct future spectrum auctions, they should consider these alternatives, to avoid the serious problems caused by the CCA + set-asides implementation in the Canadian 600 MHz spectrum auction.

References

Ausubel, Lawrence M., Christina Aperjis, and Oleg Baranov (2017), “Market Design and the FCC Incentive Auction,” Working paper, available at http://obaranov.com/docs/Ausubel-Aperjis-Baranov-Incentive-Auction.pdf.

Ausubel, Lawrence M., and Oleg Baranov (2017), "A Practical Guide to the Combinatorial Clock Auction," *Economic Journal,* v. 127, 334–350.

Ausubel, Lawrence M., Peter Cramton, and Paul Milgrom (2006), “The Clock-Proxy Auction: A Practical Combinatorial Auction Design,” in Peter Cramton, Yoav Shoham, and Richard Steinberg (eds.), *Combinatorial Auctions*, Chapter 5, 115–138, MIT Press.

Innovation, Science and Economic Development Canada (2018), “Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band,” SLPB-002-18, March 2018.

Innovation, Science and Economic Development Canada (2019), “Consultation on a Policy and Licensing Framework for Spectrum in the 3500 MHz Band,” SLPB-002-19, June 2019.

Janssen, Maarten, and Bernhard Kasberger (forthcoming), “On the clock of the combinatorial clock auction,” *Theoretical Economics.*

Levin, Jonathan and Andrzej Skrzypacz (2016), “Properties of the Combinatorial Clock Auction,” *American Economic Review*, v. 106, 2528–2551.

Rogers Communications (2017), “Reply Comments to Consultation on a Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band (SLPB-005-17),” November 2017.