

## **Appendix F: Steering Experiments**

To learn about Pandora's incentive and ability to alter the music it plays in response to differences in royalty rates among record companies, I asked Pandora to conduct a number of experiments. These experiments were designed to measure listener sensitivity to changes in Pandora's music selection algorithms. These changes were designed to alter the rate at which Pandora plays sound recordings from the three major record companies, Universal Music Group ("UMG"), Sony Music ("Sony"), and Warner Music Group ("WMG"). In particular, each experiment involved playing the music of one major record company at a specified rate that differed from that record company's natural performance rate (NPR) on Pandora.

This Appendix describes those experiments and the measured listener responses. The results of these experiments strongly support the conclusion that Pandora can steer toward or away from each major record company's music without causing a significant negative reaction from Pandora's listeners.

Based on the results of these experiments, I find that it would be profitable for Pandora to enter into an agreement with any of the three major record companies on the same terms that Pandora did with Merlin. I also find that it would be profitable for Pandora to enter into an agreement with any of the three major record companies on the same terms that Pandora did with Merlin but with 30 percent steering rather than 15 percent steering.

### **1. Description of the Steering Experiments**

In the ordinary course of business, Pandora conducts controlled experiments to assess listener responses to various changes in its service. I asked Pandora to use its normal experimental methods to perform controlled experiments to measure listener responses as Pandora steers listeners toward or away from music licensed by each of the three major record companies.

My instructions to Pandora are provided at the end of this Appendix. For each major record company ("Major"), I requested four experiments: one that increased performances of that Major's tracks by 15 percent above that Major's NPR; one that increased performances by 30

percent above that Major's NPR; one that decreased performances of the Major's tracks by 15 percent below that Major's NPR; and one that decreased performances by 30 percent below that Major's NPR.<sup>1</sup> In total, twelve experiments were run, four for each of the three Majors.

Pandora randomly assigned listeners to 13 mutually exclusive groups, twelve groups that would receive an experimental treatment, the steering toward or away from the music of a Major, and one control group. The control group consisted of 10 percent of Pandora's registered listeners. The treatment groups consisted of 5 percent of registered listeners for each UMG experiment, 7 percent of registered listeners for each Sony experiment, and 8 percent of registered listeners for each WMG experiment. The size of the treatment groups was inversely correlated with the Majors' shares of performances on Pandora at their NPRs.<sup>2</sup> The combined size of all of the treatment groups was selected to encompass 80 percent of Pandora's registered listener base, following Pandora's typical experimental practice.

With the treatment and control groups identified and steering targets specified, Pandora set the experiments running mid-afternoon on Wednesday, June 4, 2014. At my request, the experiments ran for 13 weeks, and were turned off at midnight between Wednesday, September 3 and Thursday, September 4. I asked Pandora to set aside data from mid-afternoon to midnight Wednesday June 4, 2014, and to report data for 13 full weeks beginning and ending at midnight between a Wednesday and a Thursday.<sup>3</sup>

To accomplish steering, Pandora modified its music selection algorithm for listeners in treatment groups in a manner that increased or decreased the likelihood that the specified Major's music would be played. These manipulations were done in what Mr. McBride calls a "naïve" manner; smaller listener responses, possibly much smaller, would be achieved if Pandora were to optimize its steering methods, as would be in Pandora's interest in a commercial setting. Figure F.1 reports the actual level of steering achieved in each of the twelve experiments, week-by-week. The vertical axis in Figure F.1 measures the percent difference from the specified

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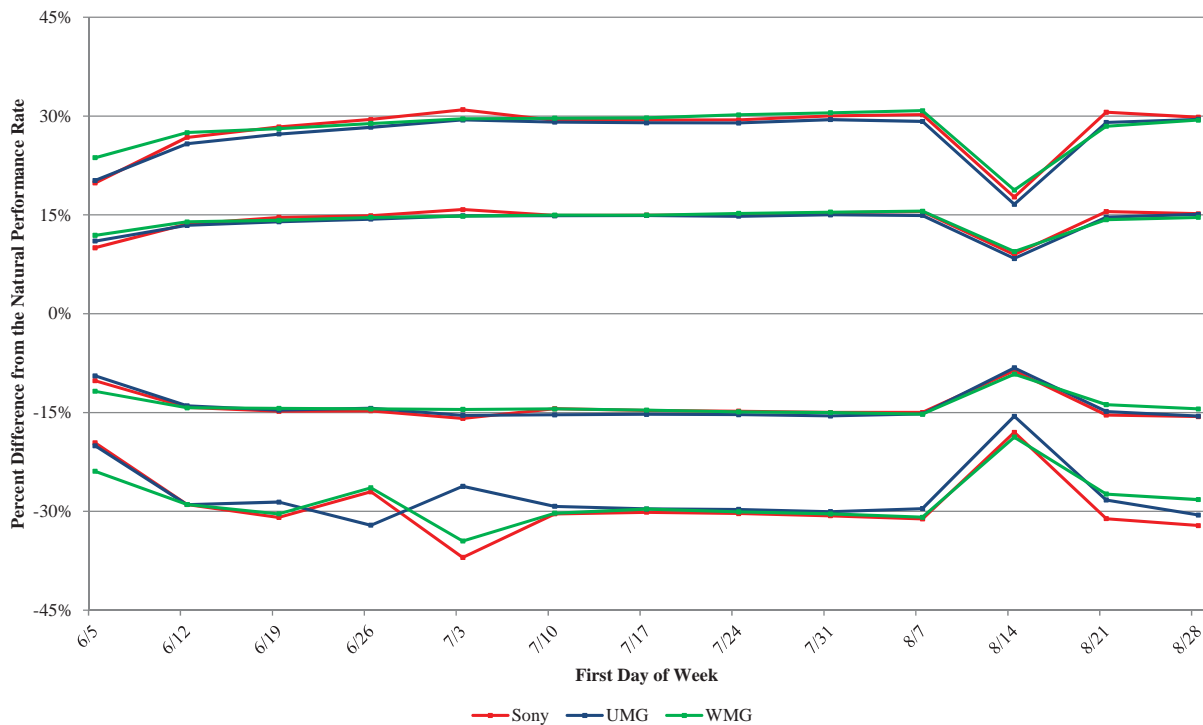
<sup>1</sup> For example, if a Major's NPR is 20 percent, increasing performances of that Major's tracks by 15 percent would raise its share of performances to 23 percent, i.e., by three percentage points (15 percent of 20 percent).

<sup>2</sup> The inverse correlation between a Major's NPR and treatment group size was selected to improve the statistical properties of the experimental results while working within the constraint that 80 percent of listeners in aggregate could be assigned to treatment groups due to Pandora's structure for conducting experiments.

<sup>3</sup> I understand there are day-of-week effects in listening habits, so I requested that the data cover a period that started and ended at the same time on the same day of the week.

Major's NPR. Figure F.1 shows that Pandora was quite successful in steering according to the target specified for each experimental group. An exception in the steering process occurred during the week beginning August 14, when the software that runs Pandora's experimental framework malfunctioned from August 18 to 20. During those three days, steering did not occur for the treatment groups, so the average steering for the week beginning August 14 was dampened. However, my conclusions discussed below are not dependent on the inclusion or exclusion of data for the week beginning August 14.

**Figure F.1**  
**Percent Increase in Performances Above Each Major's Natural Performance Rate (for Treatment Groups)**



Source: Pandora Steering Experiment Data.

Naturally, steering toward one Major necessarily means steering away from other record companies. But the arithmetic of steering implies that this “counter-steering” is milder than the specified steering toward the Major. This is because the counter-steering is spread across the other two Majors and the independent record companies (in a manner determined by Pandora's

music selection algorithms).<sup>4</sup> The same logic applies if Pandora is steering away from a Major: the resulting counter-steering toward other record companies is milder than the steering away from that Major. Furthermore, Pandora has the flexibility to counter-steer unequally among the other record companies if that would lead to a better listener experience.

## 2. Experimental Results

### *A. Hours Per Registered Listener*

The steering experiments were designed to measure the response of listeners, and thus the commercial impact on Pandora, of steering. Since roughly 80 percent of Pandora's revenues come from advertising, I focused my attention on the impact of steering on listener hours, which drives advertising revenue at Pandora.

Pandora routinely tracks listener hours when it runs experiments in the normal course of business. "Hours per registered listener" is the standard measure of listener response that Pandora looks at when it runs experiments.<sup>5</sup> This measure captures listener habits that are highly correlated with Pandora advertising revenues. I asked Pandora to pool all the weeks of data within an experiment and report average listening hour results on that basis.

### *B. Impact of Steering on Average Listening Hours*

At my request, for each experiment, Pandora calculated the difference in average listening hours between the treatment group and the control group. This difference was expressed as a percentage of the control group's average listening hours. Because the reported percentage difference in listening hours is calculated using samples of listeners that comprise the

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<sup>4</sup> To illustrate, suppose Pandora steers 30 percent toward a Major with a 20 percent NPR, raising its share of performances from 20 percent to 26 percent. Suppose that this additional 6 percent of performances comes at the expense of all other labels proportional to their NPRs. Suppose that another Major also has an NPR of 20 percent. Then that Major's share of reduced performances is only 1.5 percent of all performances (since this Major need only absorb 25 percent of the 6 percent of all performances lost to the first Major). This corresponds to steering away from the second Major by only 7.5 percent (1.5 percent divided by 20 percent). More generally, if a Major has an NPR of  $S$ , and Pandora increases that Major's performances by a factor  $(1+K)$ , that will raise this Major's share of plays from  $S$  to  $S(1+K)$ . Therefore, the other labels together must lose a combined share of performances equal to  $SK$ . Their initial share was  $(1-S)$ , so as a fraction of their initial plays, they are losing  $SK/(1-S)$ . So long as the Major's share is less than 50 percent,  $S/(1-S)$  is less than unity, so  $SK/(1-S)$  is less than  $K$ . The largest Major, UMG, has an NPR of 34 percent; for UMG,  $S/(1-S)$  is about one-half.

<sup>5</sup> Written Direct Testimony of Timothy Westergren ("Westergren Testimony") at ¶35.

treatment and control groups, this measure is an unbiased point estimate of the true value of the average listener response. Following its normal procedures, Pandora calculated confidence intervals around that point estimate, which indicate a range that, with 95% probability, encompasses the true value of the percent difference in average listening hours with versus without steering. In the discussion that follows, I focus on the point estimates of the average percentage difference in listening between treatment groups and the control group. These results are set out in Table F.1.



As one would expect, the percentage change in listening hours due to steering typically is negative.<sup>6</sup> A decrease in average listening hours is expected if Pandora is doing a good job of choosing music that optimizes the listener's experience. A departure from NPRs should then result in a somewhat less attractive listening experience, and listening hours would be more likely to fall than to increase, if they change at all. However, based on a very general proposition

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<sup>6</sup> The three exceptions out of the twelve experiments are the *positive* effects on the difference in average listening hours observed when Sony or WMG music is performed with 15 percent less frequency, and when UMG music is performed with 15 percent greater frequency.

from the mathematics of optimization, if Pandora’s playlist-selecting algorithm is optimized, the impact on listening hours from a small amount of steering should be negligible.<sup>7</sup> The experimental results are consistent with this theoretical prediction.

### *C. Interpretation of the Experimental Results*

The key finding from these experiments is that the percent change in listening hours is very small, especially for the experiments that involved 15 percent steering toward a Major, which is the most relevant for assessing an agreement like the Merlin Agreement.<sup>8</sup> To illustrate, consider the impact of steering 15 percent toward Sony, which generated the largest response among the three experiments involving 15 percent positive steering. Sony’s NPR on Pandora is [REDACTED], so steering 15 percent toward Sony involves playing Sony music an extra [REDACTED] of the time (15 percent times [REDACTED]).<sup>9</sup> This caused a drop in listening hours of [REDACTED], about one listening hour out of every [REDACTED]. Below, in Table F.2, I show that this drop in listening hours is far below the level that would make it unprofitable for Pandora to steer in this manner.

Listener responses to 30 percent steering are not as small, but they are all still well below [REDACTED]. To illustrate, again consider Sony. Steering 30 percent toward Sony involves playing Sony music an additional [REDACTED] of the time (30 percent times Sony’s NPR of [REDACTED]), about one in [REDACTED] songs extra. This resulted in a drop in average listening hours of [REDACTED], about one listening hour out of every [REDACTED]. For UMG, with its NPR of [REDACTED], 30 percent steering toward UMG involves playing UMG music an additional [REDACTED]. This resulted in a drop in listening hours of only [REDACTED]. Below, in Table F.3, I show that these drops in listening hours also are far below the level that would make it unprofitable for Pandora to steer in this manner.

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<sup>7</sup> Technically, the derivative of listening hours with respect to the amount of steering should be zero when all labels are played at their NPR. This is an application of the envelope theorem from calculus.

<sup>8</sup> Indeed, the listener response to steering toward or away from a Major by 15 percent is not statistically different from zero in any of the six experiments, and it is only statistically different from zero in the experiment that steers 30 percent away from UMG and the experiment that steers 30 percent toward Sony.

<sup>9</sup> Pandora provided me with data that reported the NPR for each Major based on Control group listening during the period of the steering experiments. See “Shapiro\_spin\_share.csv.”

These experiments provide outstanding and convincing evidence regarding the effects of steering on listening hours over a period of several months. Given the duration of these experiments, 13 weeks, they cannot measure the effects of steering over a longer period of time. In theory, the effects of steering could build up over time, in which case the longer-term effects on listening hours would be larger than found in these experiments, or they could dissipate over time, in which case the longer-term effects on listening hours would be smaller than found in these experiments.

I did not find statistically significant evidence of either of these effects in the data for the steering experiments that involved steering 15 percent toward the Majors. Using weekly data from those steering experiments, I investigated the time trend in the responses of the treatment groups to the steering. I found that the time trend in listener responses to steering 15 percent toward Sony and WMG was statistically insignificant, consistent with the hypothesis that the effects of steering on listener satisfaction neither cumulate nor dissipate over time. For the experiments that steered 15 percent toward UMG, the time trend was statistically significant but indicated that the effects of steering were dissipating, i.e., listeners were becoming *less* displeased over time. I therefore conclude that these experimental results are unlikely to underestimate the longer-term effects of steering at the 15 percent level on listening hours.<sup>10</sup>

In sum, these experimental results establish that Pandora has a great deal of flexibility to alter the mix of the music it plays with little or no impact on the listening experience, as measured by average listener hours. This translates directly into a high elasticity of demand by Pandora for the repertoire of recorded music of each of the major record companies.

### **3. Steering Toward a Major Would Be Profitable for Pandora**

I now demonstrate that it would be profitable for Pandora to enter into an agreement with any one of the three major record companies on the same terms that Pandora did with Merlin, including the requirement that Pandora steer at least [REDACTED] toward that Major.

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<sup>10</sup> For the experiments where Pandora increased a Major's performances by 30 percent, statistically significant negative trends in listening hours were observed. However, the time trends diminish over time, and I estimate that beyond three months, which was the length of the experiments, the cumulative effect would not be increasing further.

Table F.2 calculates the financial impact in 2015 on Pandora’s advertising-supported service of steering 15 percent toward each of UMG, Sony, and WMG.<sup>11</sup> The impact for each Major differs due to the different size of that Major at its NPR and the different impact on average listing hours from steering toward that Major. These factors are reported in the first two rows of Table F.2. The change in listening hours due to Pandora steering 15 percent toward each Major was already reported in Table F.1.



The largest element of the cost to Pandora of steering is the percentage change in average listening hours multiplied by Pandora’s projected advertising revenues of [REDACTED] for 2015. This cost is reported in the row labeled “Change in Advertising Revenue Due to Change in Listening Hours.” Due to the positive listener response in the experiment that steers

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<sup>11</sup> The impact of the steering on listening hours is the measure that links most directly to a change in Pandora’s advertising revenues, and steering on advertising-supported services offers by far the largest volume of performances over which Pandora can realize savings in royalty payments. Data reported in Appendix D reflect that advertising-supported performances are expected to account for 88 percent of all performances on Pandora in 2015.



15 percent toward UMG, Pandora actually realizes a tiny *gain* in advertising revenues of [REDACTED]. The lost advertising revenue due to steering 15 percent toward the other two Majors is [REDACTED] for Sony and [REDACTED] for WMG. Pandora also sees a small, offsetting, change in royalty costs associated with the change in listening hours. This is shown in the row “Offset: Change in Royalty Payments Due to Change in Listening Hours.” For UMG, Pandora’s royalty costs increase by the [REDACTED] due to the increased listening. Pandora’s savings from avoided royalty costs due to decreased listening are [REDACTED] for Sony and [REDACTED] for WMG. The effect of these two terms is a net benefit for Pandora of [REDACTED] due to steering toward UMG and a net cost for Pandora of [REDACTED] for steering toward Sony, and [REDACTED] for steering toward WMG.

The far larger benefits to Pandora of steering result from the lower royalty rates that Pandora pays for performances of music owned by the Major toward which Pandora is steering. For every advertising-supported performance of music of the Major in question, Pandora saves an amount per play that reflects the difference between the adjusted effective per-play rate under the Merlin Agreement of [REDACTED] and the per-play rate that Pandora would otherwise pay in 2015. The aggregate savings associated with this discount are shown in Table F.2 in the row “Lower Royalty Payments Due to Discounted Per-Play Rate.” Pandora’s saving from the discounted per-play rate is equal to [REDACTED] for UMG, [REDACTED] for Sony, and [REDACTED] for WMG.

Pandora’s savings on royalty payments are far larger than its loss of advertising revenues for each of the three Majors (for UMG there is actually a gain in advertising revenues). Indeed, as shown in the final row of Table F.2, the benefits to Pandora from steering 15 percent toward each Major is at least [REDACTED] the cost to Pandora. These multiples are highly significant. For example, the [REDACTED] ratio, which applies to Sony, tells us that steering 15 percent toward Sony, under the same terms as in the Merlin Agreement, would be profitable to Pandora even if the steering experiments have vastly underestimated the listener response to steering or otherwise greatly underestimated the cost to Pandora of steering toward Sony. Put differently, my conclusion that it would be profitable for Pandora to enter into an agreement with any of the three major record companies on the same terms that Pandora did with Merlin is very robust and thus highly reliable.

Table F.3 repeats this analysis for 30 percent steering toward each of the Majors. While this more pronounced steering causes a stronger response by listeners, it is still highly profitable for Pandora. These results are also very robust. The cost to Pandora of steering resulting from lost advertising revenues for 2015 is equal to [REDACTED] for UMG, [REDACTED] for Sony, and [REDACTED] for WMG. The offset from avoided royalty payments due to the decrease in listening hours equals [REDACTED] for UMG, [REDACTED] for Sony, and [REDACTED] for WMG. Pandora's savings in royalty payments are [REDACTED] for UMG, [REDACTED] for Sony, and [REDACTED] for WMG. With 30 percent steering toward any of the three Majors, Pandora's savings on royalty payments are still far larger than its net costs of steering. As the bottom line of Table F.3 shows, the benefits to Pandora of steering 30 percent toward a Major are at least [REDACTED] the cost to Pandora. Based on the results of these experiments, I find that it would be profitable for Pandora to enter into an agreement with any of the three major record companies on the same terms that Pandora did with Merlin but with 30 percent steering rather than 15 percent steering.



# **Pandora Music Steering Experiments: Instructions**

## **30 May 2014**

### **Carl Shapiro**

This memo describes the steering experiments I am requesting that Pandora run. The goal of these experiments is to measure the responses of Pandora listeners when Pandora adjusts the mix of music it plays either toward or away from the music licensed by specified recording companies. My understanding is that Pandora will adjust the overall mix of music played to listeners by modifying its algorithm, allowing flexibility to minimize the algorithmic departure from the baseline.

In running these experiments, I request that Pandora follow the procedures it uses when running experiments in the normal course of business to inform its business decisions. I also request that Pandora track and report the listener metrics that it normally tracks when running experiments. These metrics should be tracked separately for each treatment group and for the control group.

My expectation is that Pandora will run these experiments concurrently, starting as soon as Pandora is able to proceed. A randomly selected group of 10% of Pandora's registered listeners will constitute the control group, in keeping with Pandora's normal procedures for experiments. No listener will be enrolled in more than one steering experiment. The experiments will run through September 2, 2014. This date is chosen to give me sufficient time to evaluate the results and integrate them into my overall analysis.

### **Requested Experiments**

Each experiment specifies (a) a recording company; (b) a steering objective, i.e., a change in "spins" of a recording company's music as a percentage of spins of that recording company's music at baseline listening levels; and (c) the size of the experimental group, which should be randomly assigned from among Pandora registered listeners.

I request that experiments be run for Universal Music Group (UMG), Sony Music (Sony), and Warner Music Group (WMG). For each of these three companies, I request that Pandora run experiments with the following steering objectives: +/- 15% and +/- 30%. The size of the experimental groups should be 5% of registered listeners for each UMG experiment; 7% of registered listeners for each Sony experiment; and 8% of registered listeners for each WMG experiment.

### **Timing of Reported Metrics**

I understand that Pandora normally looks at metrics over one-week periods of time to avoid day-of-the-week effects. I ask that Pandora continue to follow this approach for the metrics reported to me. I also request that Pandora follow its normal procedures for measuring transitional impacts at the beginning of these experiments.