**Knowledge and Information Systems (Supplement)**

# The impact of data difficulty factors on classification of imbalanced and concept drifting data streams

## Supplementary materials

**Dariusz Brzezinski · Leandro Minku · Tomasz Pewinski · Jerzy Stefanowski · Artur Szumaczuk**

### A Imbalanced Data Stream Generator

To simulate different scenarios representing changes in imbalanced streams, a special data stream generator has been implemented. The generator is capable of creating highly customizable binary class distributions and can model different changes in data streams, following the criteria presented in Section 4. In the generated streams, the minority class is represented as a set of elliptical hypersphere clusters with randomly assigned centers and randomly assigned sizes (Fig. S1 illustrates them in 2D for easier interpretation). The majority class is simulated as uniformly distributed examples in the remaining attribute space, thus surrounding the shape of the minority class. The data stream characteristics are defined mainly by modifying the properties of the minority class. Following the proposed imbalanced stream drift categorization, the generator allows users to specify characteristics of a stream:

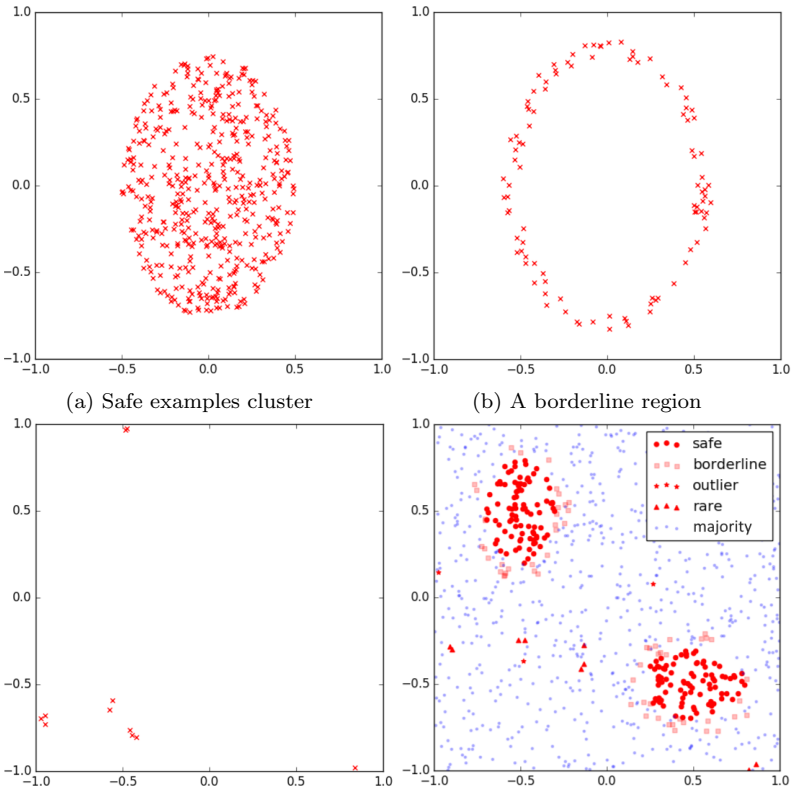
1. the *imbalance ratio*;
2. the minority *class composition* (sub-clusters);
3. *local* changes in the class distribution;
4. the *distribution of minority example types*; and
5. *drifts* that dynamically modify the definition of the minority concept.

The initial global **imbalance ratio** is defined as the probability of drawing a minority class example; the rest of the instances are drawn from the majority class. By defining a change in the imbalance ratio over time, the user can create streams with dynamic imbalance ratios. Furthermore, the generator can simulate class role swapping, i.e., scenarios where the minority class gradually becomes the majority class. In case of starting with a balanced stream, the interior cluster class is further treated as the minority class when other factors are modelled in the stream.

In terms of minority **class composition**, the generator offers the possibility of specifying the number of sub-concepts by representing the minority class as several sub-clusters. The sub-clusters are scattered randomly under the assumption that they do not overlap with each other. Moreover, it is possible to model a time changing scenario where the minority class is gradually or abruptly split into sub-clusters, or an opposite scenario where with time several sub-clusters are merged into one concept. Finally, the generator allows to model a drift of moving sub-concepts.

The **locality** of changes can be specified by changing the definition of minority sub-clusters or the definition of the entire stream. More complex global/local region drifts can also be created by combining multiple instances of generated streams.

D. Brzezinski, T. Pewinski, J. Stefanowski, A. Szumaczuk
Institute of Computing Science & Center for Artificial Intelligence and Machine Learning, Poznan University of Technology,ul. Piotrowo 2, 60-965 Poznan, Poland;
L. Minku
School of Computer Science, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom




(a) Safe examples cluster (b) A borderline region

(c) Rare examples (d) Example of a generated stream

Fig. S1: Minority class shape and sample data difficulty factors

Additionally, the generator allows to specify the **distribution of minority examples** using by setting the proportions of the following example types:

- *safe instances*, which are placed around the center of the minority clusters and do not overlap with majority samples;
- *borderline examples*, which are generated on the overlapping border between minority and majority classes[1];
- *rare examples*, placed outside of the minority clusters creating groups of few examples [2];
- *outliers*, singular minority class examples placed far away from the main clusters in random manner.

In terms of **drift** types, the generator allows to dynamically modify all of the above-mentioned minority class parameters with adjustable severity. Moreover, the generator offers the possibility of selecting the moment and rate of the change:

- *sudden drift*, where the change occurs abruptly at a given moment in time;
- *incremental drift*, where the selected stream characteristic is modified progressively over a given span of instances;

[1] Although the term borderline may also refer to examples close to complex class boundaries, in the experiments the generator considers borderline examples as those within an overlap region only

[2] They are generated as pairs or triples of minority examples, with no overlap with majority examples

– *periodical drift*, where the selected stream characteristics are modified up to a selected value and then reverted back to the starting point in a specified time interval.

The source code of a MOA-compatible implementation of the imbalanced stream generator is available at: https://github.com/dabrze/imbalanced-stream-generator.

## B Stream Naming Convention

All the data streams generated for the purposes of this study were named using a convention that mirrors the designed experiments. The assigned names consist of a set of *elements* that describe what phenomena and changes occur in a given stream. Table S1 presents the implemented naming convention. It is important to note that static changes introduced to data streams always modify initial values of variables and occur before any other changes, independently of employed naming convention.

By default, that is when no drifts or modifiers are specified, the data stream is:

1. balanced,
2. composed of single class cluster (when imbalanced this is the minority class) uniformly surrounded by examples of another class (when imbalanced this is the majority class),
3. containing only safe examples.

Table S1: Experiment naming convention

| **Element** | **Description** |
|---|---|
| + | The connected elements occur concurrently. The operator is used to create complex concept drifts. |
| StaticIm[N] | Sets an initial minority class ratio of [N]%. If not specified, the stream is considered balanced. |
| Im[N] | Specifies an imbalance ratio drift. The minority class ratio changes linearly from its initial value (balanced or specified with StaticIm) to [N]%. |
| Borderline[N] | Specifies a borderline examples ratio drift. The share of borderline examples in a minority cluster changes from the default value of 0% to [N]% in a linear fashion. |
| Rare[N] | Specifies a rare examples ratio drift. The share of rare examples in a miniority cluster changes linearly from the default value of 0% to [N]%. |
| Move[N] | Specifies a movement drift of [N] minority clusters. The drift assumes the existance of initial [N] minority clusters. |
| Split[N] | Specifies a drift, splitting the initial single minority cluster into [N] smaller disjuncts. |
| Merge[N] | Specifies a drift of merging/joining the initial [N] minority cluster into one. |
| (static) | The suffix specifies that the given stream is stationary, with a constant characteristic corresponding to the data characteristic after a drift described by the stream's name. For example, Borderline[N](static) means a stationary data stream where the ratio of borderline examples is fixed at [N]%. The (static) streams were used to verify whether the drift led to learning difficulties or whether the post-drift concept was difficult on its own (without any drift). |

Examples of using this convention are provided in Tables in the next section.

## C Averaged tabular results

We have generated 381 synthetic streams with varying data difficulty factors and drifts. The streams were either with drifts (D) or without drifts (N). Moreover, some streams contained a single data difficulty factor (S) - as described in section 4 of the main paper, whereas other streams combined several difficulties (C). Table S2 breaks down the number of streams from each group. A more detailed description of scenarios combining various elements in streams is also provided in Section 5.1 of the main paper.

Table S2: Number of experiments from each group

| | Single difficulty (S) | Combined difficulties (C) | total |
|---|---|---|---|
| No drift (N) | 29 | 132 | 224 |
| Drift (D) | 29 | 195 | 161 |
| total | 58 | 327 | 385 |

Recall that in the experiments all the generated data streams consisted of 200,000 examples. If a drift is present in a stream, it spans from example number 70,000 to 100,000. For combined scenarios all drifts occur together at the same time in this period.

Tables S3–S4 present classifier performance averaged over entire streams according to G-mean and Recall, respectively. More on classifier performance plots for each of the listed scenarios can be found at: https://github.com/dabrze/imbalanced-stream-generator.

Table S3: G-mean results averaged over entire streams. Stream groups are denoted as follows: S - Single difficulty, C - Combined difficulties, N - No drift, D - Drift.

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Borderline100 | SD | 0.970 | 0.969 | 0.969 | 0.966 | 0.950 |
| Borderline100 (static) | SN | 0.963 | 0.963 | 0.963 | 0.961 | 0.938 |
| Borderline20 | SD | 0.978 | 0.977 | 0.978 | 0.976 | 0.957 |
| Borderline20 (static) | SN | 0.973 | 0.973 | 0.973 | 0.971 | 0.953 |
| Borderline20 + Rare20 | CD | 0.917 | 0.917 | 0.917 | 0.915 | 0.899 |
| Borderline20 + Rare20 (static) | CN | 0.870 | 0.870 | 0.871 | 0.869 | 0.849 |
| Borderline40 | SD | 0.974 | 0.974 | 0.974 | 0.972 | 0.955 |
| Borderline40 (static) | SN | 0.969 | 0.968 | 0.969 | 0.966 | 0.949 |
| Borderline40 + Rare40 | CD | 0.837 | 0.836 | 0.837 | 0.834 | 0.827 |
| Borderline40 + Rare40 (static) | CN | 0.752 | 0.751 | 0.751 | 0.751 | 0.732 |
| Borderline60 | SD | 0.972 | 0.972 | 0.972 | 0.969 | 0.953 |
| Borderline60 (static) | SN | 0.967 | 0.966 | 0.967 | 0.965 | 0.944 |
| Borderline80 | SD | 0.971 | 0.970 | 0.971 | 0.968 | 0.952 |
| Borderline80 (static) | SN | 0.964 | 0.964 | 0.965 | 0.962 | 0.940 |
| Im1 | SD | 0.987 | 0.988 | 0.984 | 0.982 | 0.963 |
| Im1 (static) | SN | 0.937 | 0.976 | 0.536 | 0.587 | 0.972 |
| Im1 + Borderline100 | CD | 0.956 | 0.964 | 0.921 | 0.911 | 0.937 |
| Im1 + Borderline100 (static) | CN | 0.807 | 0.934 | 0.000 | 0.012 | 0.829 |
| Im1 + Borderline20 | CD | 0.967 | 0.974 | 0.958 | 0.957 | 0.959 |
| Im1 + Borderline20 (static) | CN | 0.891 | 0.960 | 0.334 | 0.441 | 0.930 |
| Im1 + Borderline20 + Rare20 | CD | 0.907 | 0.915 | 0.897 | 0.898 | 0.888 |
| Im1 + Borderline20 + Rare20 (static) | CN | 0.762 | 0.828 | 0.024 | 0.209 | 0.823 |
| Im1 + Borderline40 | CD | 0.951 | 0.962 | 0.934 | 0.928 | 0.951 |
| Im1 + Borderline40 (static) | CN | 0.857 | 0.952 | 0.107 | 0.227 | 0.900 |
| Im1 + Borderline40 + Rare40 | CD | 0.814 | 0.828 | 0.794 | 0.797 | 0.793 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Im1 + Borderline40 + Rare40 (static) | CN | 0.435 | 0.698 | 0.000 | 0.041 | 0.686 |
| Im1 + Borderline60 | CD | 0.948 | 0.965 | 0.917 | 0.916 | 0.948 |
| Im1 + Borderline60 (static) | CN | 0.847 | 0.945 | 0.000 | 0.060 | 0.883 |
| Im1 + Borderline80 | CD | 0.950 | 0.966 | 0.915 | 0.909 | 0.941 |
| Im1 + Borderline80 (static) | CN | 0.810 | 0.939 | 0.000 | 0.027 | 0.851 |
| Im1 + Rare100 | CD | 0.425 | 0.652 | 0.365 | 0.448 | 0.398 |
| Im1 + Rare100 (static) | CN | 0.034 | 0.522 | 0.000 | 0.076 | 0.541 |
| Im1 + Rare20 | CD | 0.924 | 0.927 | 0.924 | 0.922 | 0.887 |
| Im1 + Rare20 (static) | CN | 0.839 | 0.825 | 0.234 | 0.333 | 0.849 |
| Im1 + Rare40 | CD | 0.859 | 0.858 | 0.855 | 0.859 | 0.816 |
| Im1 + Rare40 (static) | CN | 0.681 | 0.712 | 0.071 | 0.220 | 0.746 |
| Im1 + Rare60 | CD | 0.779 | 0.778 | 0.777 | 0.791 | 0.718 |
| Im1 + Rare60 (static) | CN | 0.503 | 0.599 | 0.004 | 0.089 | 0.679 |
| Im1 + Rare80 | CD | 0.655 | 0.649 | 0.644 | 0.665 | 0.451 |
| Im1 + Rare80 (static) | CN | 0.140 | 0.523 | 0.000 | 0.076 | 0.237 |
| Im10 | SD | 0.988 | 0.988 | 0.987 | 0.984 | 0.963 |
| Im10 (static) | SN | 0.987 | 0.982 | 0.977 | 0.975 | 0.962 |
| Im10 + Borderline100 | CD | 0.967 | 0.967 | 0.955 | 0.944 | 0.949 |
| Im10 + Borderline100 (static) | CN | 0.962 | 0.954 | 0.925 | 0.912 | 0.940 |
| Im10 + Borderline20 | CD | 0.975 | 0.977 | 0.966 | 0.963 | 0.959 |
| Im10 + Borderline20 (static) | CN | 0.969 | 0.970 | 0.937 | 0.938 | 0.956 |
| Im10 + Borderline20 + Rare20 | CD | 0.913 | 0.913 | 0.903 | 0.901 | 0.899 |
| Im10 + Borderline20 + Rare20 (static) | CN | 0.868 | 0.864 | 0.833 | 0.830 | 0.850 |
| Im10 + Borderline40 | CD | 0.971 | 0.971 | 0.957 | 0.953 | 0.957 |
| Im10 + Borderline40 (static) | CN | 0.965 | 0.965 | 0.921 | 0.927 | 0.951 |
| Im10 + Borderline40 + Rare40 | CD | 0.834 | 0.835 | 0.812 | 0.811 | 0.823 |
| Im10 + Borderline40 + Rare40 (static) | CN | 0.751 | 0.749 | 0.673 | 0.674 | 0.739 |
| Im10 + Borderline60 | CD | 0.969 | 0.969 | 0.953 | 0.949 | 0.953 |
| Im10 + Borderline60 (static) | CN | 0.964 | 0.960 | 0.922 | 0.910 | 0.947 |
| Im10 + Borderline80 | CD | 0.969 | 0.968 | 0.953 | 0.945 | 0.951 |
| Im10 + Borderline80 (static) | CN | 0.963 | 0.957 | 0.923 | 0.905 | 0.944 |
| Im10 + Rare100 | CD | 0.513 | 0.676 | 0.381 | 0.431 | 0.616 |
| Im10 + Rare100 (static) | CN | 0.136 | 0.540 | 0.002 | 0.089 | 0.565 |
| Im10 + Rare20 | CD | 0.928 | 0.928 | 0.926 | 0.926 | 0.905 |
| Im10 + Rare20 (static) | CN | 0.882 | 0.872 | 0.871 | 0.863 | 0.854 |
| Im10 + Rare40 | CD | 0.859 | 0.858 | 0.857 | 0.857 | 0.837 |
| Im10 + Rare40 (static) | CN | 0.767 | 0.756 | 0.745 | 0.749 | 0.741 |
| Im10 + Rare60 | CD | 0.773 | 0.774 | 0.772 | 0.774 | 0.755 |
| Im10 + Rare60 (static) | CN | 0.625 | 0.630 | 0.560 | 0.581 | 0.643 |
| Im10 + Rare80 | CD | 0.665 | 0.667 | 0.659 | 0.663 | 0.661 |
| Im10 + Rare80 (static) | CN | 0.452 | 0.550 | 0.292 | 0.326 | 0.592 |
| Im2 | SD | 0.982 | 0.981 | 0.980 | 0.970 | 0.951 |
| Im20 | SD | 0.982 | 0.981 | 0.981 | 0.978 | 0.950 |
| Im3 | SD | 0.982 | 0.980 | 0.981 | 0.972 | 0.951 |
| Im30 | SD | 0.982 | 0.981 | 0.981 | 0.979 | 0.949 |
| Im40 | SD | 0.982 | 0.981 | 0.981 | 0.979 | 0.948 |
| Im5 | SD | 0.982 | 0.981 | 0.982 | 0.976 | 0.951 |
| Merge3 | SD | 0.965 | 0.962 | 0.963 | 0.956 | 0.908 |
| Merge3 (static) | SN | 0.990 | 0.988 | 0.990 | 0.988 | 0.947 |
| Merge5 | SD | 0.964 | 0.962 | 0.963 | 0.958 | 0.913 |
| Merge5 (static) | SN | 0.989 | 0.988 | 0.989 | 0.987 | 0.951 |
| Merge7 | SD | 0.967 | 0.964 | 0.967 | 0.956 | 0.910 |
| Merge7 (static) | SN | 0.995 | 0.994 | 0.994 | 0.993 | 0.958 |
| Move3 | SD | 0.960 | 0.959 | 0.957 | 0.950 | 0.916 |
| Move3 (static) | SN | 0.979 | 0.977 | 0.979 | 0.973 | 0.936 |
| Move5 | SD | 0.959 | 0.955 | 0.956 | 0.951 | 0.912 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Move5 (static) | SN | 0.971 | 0.968 | 0.971 | 0.965 | 0.927 |
| Move7 | SD | 0.943 | 0.937 | 0.941 | 0.929 | 0.893 |
| Move7 (static) | SN | 0.970 | 0.966 | 0.968 | 0.960 | 0.922 |
| Rare100 | SD | 0.691 | 0.677 | 0.684 | 0.682 | 0.669 |
| Rare100 (static) | SN | 0.566 | 0.554 | 0.563 | 0.530 | 0.517 |
| Rare20 | SD | 0.928 | 0.928 | 0.929 | 0.927 | 0.901 |
| Rare20 (static) | SN | 0.885 | 0.883 | 0.884 | 0.883 | 0.852 |
| Rare40 | SD | 0.858 | 0.858 | 0.859 | 0.858 | 0.834 |
| Rare40 (static) | SN | 0.766 | 0.765 | 0.766 | 0.766 | 0.737 |
| Rare60 | SD | 0.775 | 0.774 | 0.775 | 0.779 | 0.757 |
| Rare60 (static) | SN | 0.633 | 0.632 | 0.633 | 0.643 | 0.620 |
| Rare80 | SD | 0.691 | 0.679 | 0.684 | 0.701 | 0.693 |
| Rare80 (static) | SN | 0.535 | 0.519 | 0.530 | 0.546 | 0.529 |
| Split3 | SD | 0.968 | 0.967 | 0.967 | 0.963 | 0.930 |
| Split3 (static) | SN | 0.985 | 0.984 | 0.985 | 0.981 | 0.941 |
| Split5 | SD | 0.964 | 0.961 | 0.964 | 0.956 | 0.909 |
| Split5 (static) | SN | 0.970 | 0.964 | 0.969 | 0.961 | 0.921 |
| Split5 + Borderline100 | CD | 0.893 | 0.888 | 0.891 | 0.876 | 0.818 |
| Split5 + Borderline100 (static) | CN | 0.894 | 0.889 | 0.892 | 0.877 | 0.867 |
| Split5 + Borderline20 | CD | 0.941 | 0.937 | 0.941 | 0.932 | 0.892 |
| Split5 + Borderline20 (static) | CN | 0.934 | 0.931 | 0.933 | 0.926 | 0.905 |
| Split5 + Borderline20 + Rare20 | CD | 0.891 | 0.886 | 0.891 | 0.884 | 0.853 |
| Split5 + Borderline20 + Rare20 (static) | CN | 0.831 | 0.827 | 0.830 | 0.824 | 0.797 |
| Split5 + Borderline40 | CD | 0.938 | 0.934 | 0.937 | 0.928 | 0.893 |
| Split5 + Borderline40 (static) | CN | 0.916 | 0.914 | 0.915 | 0.904 | 0.892 |
| Split5 + Borderline40 + Rare40 | CD | 0.800 | 0.792 | 0.798 | 0.793 | 0.779 |
| Split5 + Borderline40 + Rare40 (static) | CN | 0.705 | 0.703 | 0.705 | 0.694 | 0.673 |
| Split5 + Borderline60 | CD | 0.935 | 0.930 | 0.934 | 0.925 | 0.892 |
| Split5 + Borderline60 (static) | CN | 0.908 | 0.903 | 0.906 | 0.891 | 0.882 |
| Split5 + Borderline80 | CD | 0.912 | 0.907 | 0.910 | 0.897 | 0.889 |
| Split5 + Borderline80 (static) | CN | 0.900 | 0.895 | 0.900 | 0.885 | 0.876 |
| Split5 + Im1 | CD | 0.884 | 0.925 | 0.782 | 0.777 | 0.779 |
| Split5 + Im1 (static) | CN | 0.702 | 0.923 | 0.000 | 0.044 | 0.769 |
| Split5 + Im1 + Borderline100 | CD | 0.754 | 0.852 | 0.628 | 0.639 | 0.656 |
| Split5 + Im1 + Borderline100 (static) | CN | 0.049 | 0.815 | 0.000 | 0.003 | 0.264 |
| Split5 + Im1 + Borderline20 | CD | 0.834 | 0.877 | 0.683 | 0.703 | 0.715 |
| Split5 + Im1 + Borderline20 (static) | CN | 0.506 | 0.897 | 0.000 | 0.005 | 0.716 |
| Split5 + Im1 + Borderline20 + Rare20 | CD | 0.748 | 0.841 | 0.610 | 0.620 | 0.647 |
| Split5 + Im1 + Borderline20 + Rare20 (static) | CN | 0.418 | 0.777 | 0.001 | 0.022 | 0.543 |
| Split5 + Im1 + Borderline40 | CD | 0.811 | 0.870 | 0.683 | 0.694 | 0.722 |
| Split5 + Im1 + Borderline40 (static) | CN | 0.486 | 0.875 | 0.000 | 0.002 | 0.700 |
| Split5 + Im1 + Borderline40 + Rare40 | CD | 0.597 | 0.748 | 0.517 | 0.559 | 0.465 |
| Split5 + Im1 + Borderline40 + Rare40 (static) | CN | 0.031 | 0.653 | 0.000 | 0.039 | 0.468 |
| Split5 + Im1 + Borderline60 | CD | 0.775 | 0.858 | 0.640 | 0.653 | 0.631 |
| Split5 + Im1 + Borderline60 (static) | CN | 0.292 | 0.853 | 0.000 | 0.004 | 0.606 |
| Split5 + Im1 + Borderline80 | CD | 0.749 | 0.850 | 0.581 | 0.584 | 0.589 |
| Split5 + Im1 + Borderline80 (static) | CN | 0.158 | 0.831 | 0.000 | 0.000 | 0.270 |
| Split5 + Im1 + Rare100 | CD | 0.454 | 0.648 | 0.374 | 0.471 | 0.464 |
| Split5 + Im1 + Rare100 (static) | CN | 0.048 | 0.536 | 0.001 | 0.087 | 0.548 |
| Split5 + Im1 + Rare20 | CD | 0.813 | 0.875 | 0.679 | 0.707 | 0.691 |
| Split5 + Im1 + Rare20 (static) | CN | 0.486 | 0.783 | 0.000 | 0.048 | 0.527 |
| Split5 + Im1 + Rare40 | CD | 0.729 | 0.812 | 0.679 | 0.687 | 0.504 |
| Split5 + Im1 + Rare40 (static) | CN | 0.430 | 0.688 | 0.001 | 0.059 | 0.540 |
| Split5 + Im1 + Rare60 | CD | 0.576 | 0.673 | 0.474 | 0.510 | 0.513 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Split5 + Im1 + Rare60 (static) | CN | 0.153 | 0.561 | 0.000 | 0.075 | 0.318 |
| Split5 + Im1 + Rare80 | CD | 0.509 | 0.589 | 0.448 | 0.506 | 0.439 |
| Split5 + Im1 + Rare80 (static) | CN | 0.031 | 0.501 | 0.001 | 0.071 | 0.233 |
| Split5 + Im10 | CD | 0.958 | 0.947 | 0.911 | 0.905 | 0.849 |
| Split5 + Im10 (static) | CN | 0.971 | 0.942 | 0.869 | 0.870 | 0.929 |
| Split5 + Im10 + Borderline100 | CD | 0.904 | 0.895 | 0.761 | 0.779 | 0.799 |
| Split5 + Im10 + Borderline100 (static) | CN | 0.883 | 0.859 | 0.343 | 0.416 | 0.872 |
| Split5 + Im10 + Borderline20 | CD | 0.940 | 0.931 | 0.880 | 0.883 | 0.843 |
| Split5 + Im10 + Borderline20 (static) | CN | 0.927 | 0.914 | 0.783 | 0.790 | 0.911 |
| Split5 + Im10 + Borderline20 + Rare20 | CD | 0.875 | 0.867 | 0.795 | 0.803 | 0.794 |
| Split5 + Im10 + Borderline20 + Rare20 (static) | CN | 0.817 | 0.802 | 0.598 | 0.602 | 0.800 |
| Split5 + Im10 + Borderline40 | CD | 0.921 | 0.913 | 0.824 | 0.824 | 0.825 |
| Split5 + Im10 + Borderline40 (static) | CN | 0.901 | 0.893 | 0.701 | 0.718 | 0.895 |
| Split5 + Im10 + Borderline40 + Rare40 | CD | 0.780 | 0.771 | 0.618 | 0.638 | 0.687 |
| Split5 + Im10 + Borderline40 + Rare40 (static) | CN | 0.653 | 0.686 | 0.186 | 0.290 | 0.673 |
| Split5 + Im10 + Borderline60 | CD | 0.910 | 0.901 | 0.786 | 0.794 | 0.812 |
| Split5 + Im10 + Borderline60 (static) | CN | 0.895 | 0.883 | 0.610 | 0.618 | 0.886 |
| Split5 + Im10 + Borderline80 | CD | 0.908 | 0.898 | 0.750 | 0.759 | 0.794 |
| Split5 + Im10 + Borderline80 (static) | CN | 0.887 | 0.866 | 0.509 | 0.557 | 0.877 |
| Split5 + Im10 + Rare100 | CD | 0.540 | 0.687 | 0.384 | 0.441 | 0.627 |
| Split5 + Im10 + Rare100 (static) | CN | 0.247 | 0.587 | 0.001 | 0.092 | 0.583 |
| Split5 + Im10 + Rare20 | CD | 0.903 | 0.887 | 0.829 | 0.827 | 0.799 |
| Split5 + Im10 + Rare20 (static) | CN | 0.862 | 0.833 | 0.705 | 0.703 | 0.814 |
| Split5 + Im10 + Rare40 | CD | 0.839 | 0.825 | 0.757 | 0.767 | 0.741 |
| Split5 + Im10 + Rare40 (static) | CN | 0.748 | 0.725 | 0.498 | 0.552 | 0.704 |
| Split5 + Im10 + Rare60 | CD | 0.743 | 0.735 | 0.577 | 0.641 | 0.664 |
| Split5 + Im10 + Rare60 (static) | CN | 0.587 | 0.614 | 0.282 | 0.334 | 0.601 |
| Split5 + Im10 + Rare80 | CD | 0.619 | 0.631 | 0.490 | 0.522 | 0.635 |
| Split5 + Im10 + Rare80 (static) | CN | 0.375 | 0.576 | 0.001 | 0.088 | 0.563 |
| Split5 + Rare100 | CD | 0.707 | 0.698 | 0.702 | 0.698 | 0.697 |
| Split5 + Rare100 (static) | CN | 0.602 | 0.590 | 0.598 | 0.575 | 0.574 |
| Split5 + Rare20 | CD | 0.901 | 0.896 | 0.901 | 0.891 | 0.843 |
| Split5 + Rare20 (static) | CN | 0.866 | 0.861 | 0.864 | 0.860 | 0.807 |
| Split5 + Rare40 | CD | 0.835 | 0.832 | 0.834 | 0.829 | 0.806 |
| Split5 + Rare40 (static) | CN | 0.751 | 0.745 | 0.750 | 0.744 | 0.689 |
| Split5 + Rare60 | CD | 0.759 | 0.753 | 0.758 | 0.761 | 0.732 |
| Split5 + Rare60 (static) | CN | 0.631 | 0.625 | 0.630 | 0.636 | 0.584 |
| Split5 + Rare80 | CD | 0.704 | 0.689 | 0.702 | 0.701 | 0.684 |
| Split5 + Rare80 (static) | CN | 0.609 | 0.589 | 0.601 | 0.579 | 0.529 |
| Split7 | SD | 0.968 | 0.965 | 0.968 | 0.962 | 0.922 |
| Split7 (static) | SN | 0.975 | 0.973 | 0.975 | 0.971 | 0.930 |
| StaticIm1 | SN | 0.886 | 0.952 | 0.024 | 0.079 | 0.870 |
| StaticIm1 + Im60 | CD | 0.918 | 0.965 | 0.602 | 0.622 | 0.913 |
| StaticIm1 + Im70 | CD | 0.919 | 0.965 | 0.605 | 0.625 | 0.916 |
| StaticIm1 + Im80 | CD | 0.918 | 0.964 | 0.608 | 0.627 | 0.911 |
| StaticIm1 + Im90 | CD | 0.918 | 0.964 | 0.612 | 0.629 | 0.913 |
| StaticIm1 + Im99 | CD | 0.919 | 0.961 | 0.611 | 0.631 | 0.895 |
| StaticIm1 + Merge3 | CD | 0.706 | 0.895 | 0.119 | 0.226 | 0.873 |
| StaticIm1 + Merge3 (static) | CN | 0.916 | 0.979 | 0.271 | 0.356 | 0.948 |
| StaticIm1 + Merge5 | CD | 0.735 | 0.926 | 0.225 | 0.333 | 0.888 |
| StaticIm1 + Merge5 (static) | CN | 0.912 | 0.980 | 0.469 | 0.504 | 0.973 |
| StaticIm1 + Merge7 | CD | 0.710 | 0.925 | 0.308 | 0.416 | 0.887 |
| StaticIm1 + Merge7 (static) | CN | 0.962 | 0.985 | 0.575 | 0.643 | 0.977 |
| StaticIm1 + Move3 | CD | 0.699 | 0.907 | 0.000 | 0.058 | 0.809 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm1 + Move3 (static) | CN | 0.743 | 0.939 | 0.000 | 0.009 | 0.825 |
| StaticIm1 + Move5 | CD | 0.653 | 0.920 | 0.001 | 0.020 | 0.784 |
| StaticIm1 + Move5 (static) | CN | 0.691 | 0.923 | 0.000 | 0.011 | 0.784 |
| StaticIm1 + Move7 | CD | 0.568 | 0.919 | 0.000 | 0.011 | 0.766 |
| StaticIm1 + Move7 (static) | CN | 0.676 | 0.899 | 0.000 | 0.020 | 0.782 |
| StaticIm1 + Split3 | CD | 0.753 | 0.892 | 0.184 | 0.299 | 0.905 |
| StaticIm1 + Split3 (static) | CN | 0.797 | 0.940 | 0.009 | 0.022 | 0.867 |
| StaticIm1 + Split5 | CD | 0.605 | 0.826 | 0.160 | 0.200 | 0.717 |
| StaticIm1 + Split5 (static) | CN | 0.643 | 0.906 | 0.000 | 0.018 | 0.753 |
| StaticIm1 + Split7 | CD | 0.680 | 0.880 | 0.150 | 0.263 | 0.847 |
| StaticIm1 + Split7 (static) | CN | 0.675 | 0.921 | 0.000 | 0.063 | 0.806 |
| StaticIm10 | SN | 0.988 | 0.983 | 0.977 | 0.974 | 0.963 |
| StaticIm10 (static) | SN | 0.988 | 0.983 | 0.977 | 0.974 | 0.963 |
| StaticIm10 + Borderline100 | CD | 0.963 | 0.966 | 0.907 | 0.903 | 0.952 |
| StaticIm10 + Borderline100 (static) | CN | 0.962 | 0.954 | 0.925 | 0.912 | 0.940 |
| StaticIm10 + Borderline20 | CD | 0.972 | 0.975 | 0.952 | 0.947 | 0.960 |
| StaticIm10 + Borderline20 (static) | CN | 0.969 | 0.970 | 0.938 | 0.938 | 0.956 |
| StaticIm10 + Borderline20 + Rare20 | CD | 0.910 | 0.913 | 0.888 | 0.885 | 0.900 |
| StaticIm10 + Borderline20 + Rare20 (static) | CN | 0.868 | 0.863 | 0.834 | 0.830 | 0.851 |
| StaticIm10 + Borderline40 | CD | 0.968 | 0.972 | 0.938 | 0.931 | 0.959 |
| StaticIm10 + Borderline40 (static) | CN | 0.966 | 0.966 | 0.926 | 0.927 | 0.951 |
| StaticIm10 + Borderline40 + Rare40 | CD | 0.831 | 0.837 | 0.784 | 0.778 | 0.829 |
| StaticIm10 + Borderline40 + Rare40 (static) | CN | 0.750 | 0.749 | 0.671 | 0.654 | 0.739 |
| StaticIm10 + Borderline60 | CD | 0.966 | 0.970 | 0.925 | 0.918 | 0.956 |
| StaticIm10 + Borderline60 (static) | CN | 0.964 | 0.960 | 0.918 | 0.911 | 0.947 |
| StaticIm10 + Borderline80 | CD | 0.964 | 0.968 | 0.914 | 0.909 | 0.954 |
| StaticIm10 + Borderline80 (static) | CN | 0.963 | 0.957 | 0.921 | 0.905 | 0.944 |
| StaticIm10 + Im1 | CD | 0.983 | 0.983 | 0.949 | 0.912 | 0.965 |
| StaticIm10 + Im1 (static) | CN | 0.937 | 0.977 | 0.544 | 0.582 | 0.971 |
| StaticIm10 + Im1 + Borderline100 | CD | 0.939 | 0.963 | 0.700 | 0.743 | 0.952 |
| StaticIm10 + Im1 + Borderline100 (static) | CN | 0.799 | 0.936 | 0.002 | 0.037 | 0.824 |
| StaticIm10 + Im1 + Borderline20 | CD | 0.955 | 0.974 | 0.905 | 0.883 | 0.960 |
| StaticIm10 + Im1 + Borderline20 (static) | CN | 0.886 | 0.961 | 0.340 | 0.440 | 0.927 |
| StaticIm10 + Im1 + Borderline20 + Rare20 | CD | 0.895 | 0.913 | 0.829 | 0.840 | 0.890 |
| StaticIm10 + Im1 + Borderline20 + Rare20 (static) | CN | 0.776 | 0.831 | 0.081 | 0.234 | 0.820 |
| StaticIm10 + Im1 + Borderline40 | CD | 0.935 | 0.969 | 0.854 | 0.823 | 0.958 |
| StaticIm10 + Im1 + Borderline40 (static) | CN | 0.854 | 0.952 | 0.039 | 0.216 | 0.895 |
| StaticIm10 + Im1 + Borderline40 + Rare40 | CD | 0.788 | 0.837 | 0.660 | 0.710 | 0.813 |
| StaticIm10 + Im1 + Borderline40 + Rare40 (static) | CN | 0.509 | 0.696 | 0.000 | 0.038 | 0.684 |
| StaticIm10 + Im1 + Borderline60 | CD | 0.930 | 0.966 | 0.798 | 0.851 | 0.957 |
| StaticIm10 + Im1 + Borderline60 (static) | CN | 0.837 | 0.946 | 0.000 | 0.041 | 0.871 |
| StaticIm10 + Im1 + Borderline80 | CD | 0.932 | 0.963 | 0.723 | 0.715 | 0.952 |
| StaticIm10 + Im1 + Borderline80 (static) | CN | 0.773 | 0.940 | 0.000 | 0.012 | 0.846 |
| StaticIm10 + Im1 + Rare100 | CD | 0.385 | 0.358 | 0.344 | 0.407 | 0.695 |
| StaticIm10 + Im1 + Rare100 (static) | CN | 0.049 | 0.515 | 0.000 | 0.084 | 0.549 |
| StaticIm10 + Im1 + Rare20 | CD | 0.920 | 0.919 | 0.872 | 0.845 | 0.900 |
| StaticIm10 + Im1 + Rare20 (static) | CN | 0.826 | 0.832 | 0.320 | 0.425 | 0.856 |
| StaticIm10 + Im1 + Rare40 | CD | 0.849 | 0.848 | 0.793 | 0.758 | 0.819 |
| StaticIm10 + Im1 + Rare40 (static) | CN | 0.677 | 0.709 | 0.074 | 0.152 | 0.737 |
| StaticIm10 + Im1 + Rare60 | CD | 0.775 | 0.771 | 0.697 | 0.683 | 0.781 |
| StaticIm10 + Im1 + Rare60 (static) | CN | 0.452 | 0.600 | 0.008 | 0.095 | 0.659 |
| StaticIm10 + Im1 + Rare80 | CD | 0.650 | 0.654 | 0.588 | 0.622 | 0.701 |
| StaticIm10 + Im1 + Rare80 (static) | CN | 0.174 | 0.522 | 0.000 | 0.068 | 0.223 |
| StaticIm10 + Im2 | CD | 0.983 | 0.970 | 0.902 | 0.913 | 0.952 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm10 + Im3 | CD | 0.983 | 0.970 | 0.927 | 0.926 | 0.952 |
| StaticIm10 + Im5 | CD | 0.983 | 0.972 | 0.948 | 0.945 | 0.951 |
| StaticIm10 + Im60 | CD | 0.983 | 0.974 | 0.967 | 0.963 | 0.940 |
| StaticIm10 + Im70 | CD | 0.983 | 0.974 | 0.967 | 0.964 | 0.942 |
| StaticIm10 + Im80 | CD | 0.983 | 0.973 | 0.967 | 0.964 | 0.939 |
| StaticIm10 + Im90 | CD | 0.983 | 0.973 | 0.967 | 0.964 | 0.939 |
| StaticIm10 + Merge3 | CD | 0.966 | 0.953 | 0.860 | 0.857 | 0.925 |
| StaticIm10 + Merge3 (static) | CN | 0.989 | 0.984 | 0.977 | 0.975 | 0.954 |
| StaticIm10 + Merge5 | CD | 0.965 | 0.949 | 0.859 | 0.841 | 0.921 |
| StaticIm10 + Merge5 (static) | CN | 0.987 | 0.984 | 0.967 | 0.959 | 0.956 |
| StaticIm10 + Merge7 | CD | 0.967 | 0.955 | 0.849 | 0.858 | 0.921 |
| StaticIm10 + Merge7 (static) | CN | 0.993 | 0.991 | 0.987 | 0.985 | 0.963 |
| StaticIm10 + Move3 | CD | 0.954 | 0.939 | 0.816 | 0.814 | 0.919 |
| StaticIm10 + Move3 (static) | CN | 0.976 | 0.964 | 0.922 | 0.919 | 0.943 |
| StaticIm10 + Move5 | CD | 0.950 | 0.931 | 0.806 | 0.799 | 0.910 |
| StaticIm10 + Move5 (static) | CN | 0.971 | 0.945 | 0.875 | 0.872 | 0.933 |
| StaticIm10 + Move7 | CD | 0.947 | 0.935 | 0.790 | 0.803 | 0.914 |
| StaticIm10 + Move7 (static) | CN | 0.970 | 0.941 | 0.878 | 0.880 | 0.930 |
| StaticIm10 + Rare100 | CD | 0.458 | 0.583 | 0.348 | 0.397 | 0.699 |
| StaticIm10 + Rare100 (static) | CN | 0.145 | 0.539 | 0.001 | 0.094 | 0.557 |
| StaticIm10 + Rare20 | CD | 0.926 | 0.921 | 0.915 | 0.914 | 0.901 |
| StaticIm10 + Rare20 (static) | CN | 0.881 | 0.873 | 0.870 | 0.862 | 0.855 |
| StaticIm10 + Rare40 | CD | 0.857 | 0.853 | 0.845 | 0.845 | 0.836 |
| StaticIm10 + Rare40 (static) | CN | 0.765 | 0.757 | 0.745 | 0.749 | 0.740 |
| StaticIm10 + Rare60 | CD | 0.772 | 0.770 | 0.761 | 0.762 | 0.773 |
| StaticIm10 + Rare60 (static) | CN | 0.624 | 0.631 | 0.562 | 0.577 | 0.646 |
| StaticIm10 + Rare80 | CD | 0.666 | 0.680 | 0.647 | 0.651 | 0.723 |
| StaticIm10 + Rare80 (static) | CN | 0.448 | 0.543 | 0.297 | 0.323 | 0.586 |
| StaticIm10 + Split3 | CD | 0.959 | 0.960 | 0.867 | 0.868 | 0.938 |
| StaticIm10 + Split3 (static) | CN | 0.978 | 0.965 | 0.920 | 0.917 | 0.943 |
| StaticIm10 + Split5 | CD | 0.957 | 0.952 | 0.850 | 0.861 | 0.932 |
| StaticIm10 + Split5 (static) | CN | 0.973 | 0.957 | 0.898 | 0.896 | 0.941 |
| StaticIm10 + Split5 + Borderline100 | CD | 0.894 | 0.902 | 0.602 | 0.651 | 0.895 |
| StaticIm10 + Split5 + Borderline100 (static) | CN | 0.894 | 0.871 | 0.507 | 0.552 | 0.881 |
| StaticIm10 + Split5 + Borderline20 | CD | 0.940 | 0.940 | 0.834 | 0.841 | 0.928 |
| StaticIm10 + Split5 + Borderline20 (static) | CN | 0.933 | 0.928 | 0.825 | 0.824 | 0.922 |
| StaticIm10 + Split5 + Borderline20 + Rare20 | CD | 0.868 | 0.860 | 0.697 | 0.719 | 0.854 |
| StaticIm10 + Split5 + Borderline20 + Rare20 (static) | CN | 0.826 | 0.821 | 0.652 | 0.684 | 0.813 |
| StaticIm10 + Split5 + Borderline40 | CD | 0.923 | 0.930 | 0.774 | 0.789 | 0.918 |
| StaticIm10 + Split5 + Borderline40 (static) | CN | 0.914 | 0.909 | 0.758 | 0.779 | 0.909 |
| StaticIm10 + Split5 + Borderline40 + Rare40 | CD | 0.768 | 0.763 | 0.477 | 0.536 | 0.783 |
| StaticIm10 + Split5 + Borderline40 + Rare40 (static) | CN | 0.679 | 0.695 | 0.305 | 0.386 | 0.693 |
| StaticIm10 + Split5 + Borderline60 | CD | 0.909 | 0.912 | 0.673 | 0.709 | 0.907 |
| StaticIm10 + Split5 + Borderline60 (static) | CN | 0.906 | 0.895 | 0.677 | 0.709 | 0.894 |
| StaticIm10 + Split5 + Borderline80 | CD | 0.903 | 0.908 | 0.675 | 0.699 | 0.908 |
| StaticIm10 + Split5 + Borderline80 (static) | CN | 0.897 | 0.882 | 0.602 | 0.628 | 0.888 |
| StaticIm10 + Split5 + Im1 | CD | 0.801 | 0.898 | 0.454 | 0.498 | 0.825 |
| StaticIm10 + Split5 + Im1 (static) | CN | 0.757 | 0.940 | 0.000 | 0.031 | 0.824 |
| StaticIm10 + Split5 + Im1 + Borderline100 | CD | 0.643 | 0.844 | 0.404 | 0.412 | 0.772 |
| StaticIm10 + Split5 + Im1 + Borderline100 (static) | CN | 0.217 | 0.842 | 0.000 | 0.005 | 0.536 |
| StaticIm10 + Split5 + Im1 + Borderline20 | CD | 0.787 | 0.898 | 0.449 | 0.488 | 0.824 |
| StaticIm10 + Split5 + Im1 + Borderline20 (static) | CN | 0.651 | 0.909 | 0.000 | 0.012 | 0.773 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm10 + Split5 + Im1 + Borderline20 + Rare20 | CD | 0.688 | 0.820 | 0.446 | 0.465 | 0.772 |
| StaticIm10 + Split5 + Im1 + Borderline20 + Rare20 (static) | CN | 0.490 | 0.796 | 0.002 | 0.030 | 0.648 |
| StaticIm10 + Split5 + Im1 + Borderline40 | CD | 0.760 | 0.858 | 0.436 | 0.498 | 0.795 |
| StaticIm10 + Split5 + Im1 + Borderline40 (static) | CN | 0.535 | 0.885 | 0.000 | 0.004 | 0.676 |
| StaticIm10 + Split5 + Im1 + Borderline40 + Rare40 | CD | 0.561 | 0.686 | 0.419 | 0.444 | 0.674 |
| StaticIm10 + Split5 + Im1 + Borderline40 + Rare40 (static) | CN | 0.101 | 0.665 | 0.001 | 0.039 | 0.350 |
| StaticIm10 + Split5 + Im1 + Borderline60 | CD | 0.709 | 0.849 | 0.465 | 0.498 | 0.780 |
| StaticIm10 + Split5 + Im1 + Borderline60 (static) | CN | 0.468 | 0.874 | 0.000 | 0.011 | 0.441 |
| StaticIm10 + Split5 + Im1 + Borderline80 | CD | 0.680 | 0.851 | 0.452 | 0.484 | 0.771 |
| StaticIm10 + Split5 + Im1 + Borderline80 (static) | CN | 0.342 | 0.854 | 0.000 | 0.000 | 0.572 |
| StaticIm10 + Split5 + Im1 + Rare100 | CD | 0.387 | 0.364 | 0.343 | 0.406 | 0.702 |
| StaticIm10 + Split5 + Im1 + Rare100 (static) | CN | 0.050 | 0.525 | 0.000 | 0.073 | 0.575 |
| StaticIm10 + Split5 + Im1 + Rare20 | CD | 0.753 | 0.836 | 0.445 | 0.490 | 0.794 |
| StaticIm10 + Split5 + Im1 + Rare20 (static) | CN | 0.598 | 0.806 | 0.000 | 0.016 | 0.716 |
| StaticIm10 + Split5 + Im1 + Rare40 | CD | 0.647 | 0.744 | 0.423 | 0.454 | 0.744 |
| StaticIm10 + Split5 + Im1 + Rare40 (static) | CN | 0.405 | 0.675 | 0.003 | 0.049 | 0.457 |
| StaticIm10 + Split5 + Im1 + Rare60 | CD | 0.599 | 0.627 | 0.448 | 0.465 | 0.692 |
| StaticIm10 + Split5 + Im1 + Rare60 (static) | CN | 0.212 | 0.571 | 0.002 | 0.063 | 0.526 |
| StaticIm10 + Split5 + Im1 + Rare80 | CD | 0.475 | 0.498 | 0.414 | 0.443 | 0.681 |
| StaticIm10 + Split5 + Im1 + Rare80 (static) | CN | 0.028 | 0.482 | 0.001 | 0.050 | 0.522 |
| StaticIm10 + Split5 + Rare100 | CD | 0.499 | 0.609 | 0.355 | 0.399 | 0.718 |
| StaticIm10 + Split5 + Rare100 (static) | CN | 0.231 | 0.579 | 0.001 | 0.097 | 0.578 |
| StaticIm10 + Split5 + Rare20 | CD | 0.895 | 0.883 | 0.758 | 0.768 | 0.868 |
| StaticIm10 + Split5 + Rare20 (static) | CN | 0.868 | 0.842 | 0.730 | 0.737 | 0.822 |
| StaticIm10 + Split5 + Rare40 | CD | 0.830 | 0.810 | 0.676 | 0.690 | 0.800 |
| StaticIm10 + Split5 + Rare40 (static) | CN | 0.749 | 0.731 | 0.570 | 0.585 | 0.710 |
| StaticIm10 + Split5 + Rare60 | CD | 0.743 | 0.734 | 0.555 | 0.586 | 0.748 |
| StaticIm10 + Split5 + Rare60 (static) | CN | 0.597 | 0.616 | 0.333 | 0.411 | 0.612 |
| StaticIm10 + Split5 + Rare80 | CD | 0.615 | 0.672 | 0.404 | 0.457 | 0.714 |
| StaticIm10 + Split5 + Rare80 (static) | CN | 0.376 | 0.583 | 0.012 | 0.116 | 0.570 |
| StaticIm10 + Split7 | CD | 0.937 | 0.943 | 0.798 | 0.806 | 0.913 |
| StaticIm10 + Split7 (static) | CN | 0.974 | 0.953 | 0.899 | 0.895 | 0.935 |
| StaticIm2 | SN | 0.954 | 0.958 | 0.418 | 0.477 | 0.951 |
| StaticIm2 + Im1 | CD | 0.942 | 0.957 | 0.131 | 0.264 | 0.940 |
| StaticIm2 + Im60 | CD | 0.963 | 0.968 | 0.682 | 0.739 | 0.939 |
| StaticIm2 + Im70 | CD | 0.964 | 0.968 | 0.684 | 0.741 | 0.940 |
| StaticIm2 + Im80 | CD | 0.963 | 0.966 | 0.684 | 0.741 | 0.939 |
| StaticIm2 + Im90 | CD | 0.963 | 0.967 | 0.685 | 0.743 | 0.938 |
| StaticIm2 + Im98 | CD | 0.963 | 0.965 | 0.686 | 0.743 | 0.931 |
| StaticIm20 | SD | 0.983 | 0.977 | 0.981 | 0.978 | 0.947 |
| StaticIm20 + Im1 | CD | 0.981 | 0.975 | 0.941 | 0.961 | 0.951 |
| StaticIm20 + Im10 | CD | 0.983 | 0.977 | 0.979 | 0.976 | 0.950 |
| StaticIm20 + Im2 | CD | 0.983 | 0.976 | 0.961 | 0.967 | 0.952 |
| StaticIm20 + Im3 | CD | 0.983 | 0.976 | 0.965 | 0.970 | 0.952 |
| StaticIm20 + Im5 | CD | 0.983 | 0.977 | 0.973 | 0.972 | 0.952 |
| StaticIm20 + Im60 | CD | 0.983 | 0.977 | 0.980 | 0.979 | 0.944 |
| StaticIm20 + Im70 | CD | 0.983 | 0.977 | 0.980 | 0.980 | 0.944 |
| StaticIm20 + Im80 | CD | 0.982 | 0.976 | 0.980 | 0.978 | 0.942 |

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**Table S3 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm20 + Im90 | CD | 0.983 | 0.977 | 0.980 | 0.978 | 0.940 |
| StaticIm3 | SN | 0.974 | 0.960 | 0.665 | 0.695 | 0.957 |
| StaticIm3 + Im1 | CD | 0.967 | 0.960 | 0.328 | 0.451 | 0.951 |
| StaticIm3 + Im2 | CD | 0.972 | 0.960 | 0.564 | 0.619 | 0.958 |
| StaticIm3 + Im60 | CD | 0.976 | 0.968 | 0.790 | 0.820 | 0.942 |
| StaticIm3 + Im70 | CD | 0.976 | 0.968 | 0.790 | 0.821 | 0.942 |
| StaticIm3 + Im80 | CD | 0.976 | 0.967 | 0.789 | 0.819 | 0.941 |
| StaticIm3 + Im90 | CD | 0.976 | 0.967 | 0.790 | 0.820 | 0.940 |
| StaticIm3 + Im97 | CD | 0.975 | 0.965 | 0.789 | 0.819 | 0.938 |
| StaticIm30 | SN | 0.983 | 0.980 | 0.982 | 0.980 | 0.951 |
| StaticIm30 + Im1 | CD | 0.981 | 0.979 | 0.973 | 0.951 | 0.951 |
| StaticIm30 + Im10 | CD | 0.983 | 0.979 | 0.981 | 0.975 | 0.953 |
| StaticIm30 + Im2 | CD | 0.982 | 0.978 | 0.976 | 0.964 | 0.953 |
| StaticIm30 + Im20 | CD | 0.983 | 0.979 | 0.982 | 0.978 | 0.951 |
| StaticIm30 + Im3 | CD | 0.983 | 0.979 | 0.978 | 0.968 | 0.954 |
| StaticIm30 + Im5 | CD | 0.983 | 0.979 | 0.979 | 0.973 | 0.953 |
| StaticIm30 + Im60 | CD | 0.982 | 0.979 | 0.982 | 0.980 | 0.947 |
| StaticIm30 + Im70 | CD | 0.982 | 0.980 | 0.982 | 0.979 | 0.946 |
| StaticIm30 + Im80 | CD | 0.982 | 0.979 | 0.981 | 0.979 | 0.945 |
| StaticIm30 + Im90 | CD | 0.982 | 0.979 | 0.981 | 0.979 | 0.943 |
| StaticIm40 | SN | 0.983 | 0.981 | 0.983 | 0.980 | 0.954 |
| StaticIm40 + Im1 | CD | 0.982 | 0.980 | 0.976 | 0.969 | 0.938 |
| StaticIm40 + Im10 | CD | 0.982 | 0.980 | 0.982 | 0.977 | 0.954 |
| StaticIm40 + Im2 | CD | 0.982 | 0.979 | 0.980 | 0.974 | 0.952 |
| StaticIm40 + Im20 | CD | 0.983 | 0.980 | 0.982 | 0.979 | 0.955 |
| StaticIm40 + Im3 | CD | 0.983 | 0.980 | 0.981 | 0.976 | 0.953 |
| StaticIm40 + Im30 | CD | 0.983 | 0.980 | 0.983 | 0.980 | 0.955 |
| StaticIm40 + Im5 | CD | 0.983 | 0.980 | 0.982 | 0.976 | 0.954 |
| StaticIm40 + Im60 | CD | 0.982 | 0.980 | 0.982 | 0.979 | 0.951 |
| StaticIm40 + Im70 | CD | 0.982 | 0.980 | 0.982 | 0.979 | 0.949 |
| StaticIm40 + Im80 | CD | 0.982 | 0.980 | 0.981 | 0.979 | 0.946 |
| StaticIm40 + Im90 | CD | 0.982 | 0.980 | 0.982 | 0.979 | 0.946 |
| StaticIm5 | SN | 0.981 | 0.965 | 0.878 | 0.881 | 0.952 |
| StaticIm5 + Im1 | CD | 0.974 | 0.962 | 0.541 | 0.525 | 0.953 |
| StaticIm5 + Im2 | CD | 0.980 | 0.963 | 0.755 | 0.742 | 0.955 |
| StaticIm5 + Im3 | CD | 0.981 | 0.964 | 0.829 | 0.838 | 0.954 |
| StaticIm5 + Im60 | CD | 0.982 | 0.971 | 0.909 | 0.917 | 0.940 |
| StaticIm5 + Im70 | CD | 0.982 | 0.971 | 0.909 | 0.917 | 0.939 |
| StaticIm5 + Im80 | CD | 0.981 | 0.969 | 0.908 | 0.916 | 0.938 |
| StaticIm5 + Im90 | CD | 0.982 | 0.970 | 0.909 | 0.917 | 0.937 |
| StaticIm5 + Im95 | CD | 0.981 | 0.970 | 0.908 | 0.916 | 0.937 |
| StaticIm50 | SD | 0.982 | 0.981 | 0.981 | 0.979 | 0.947 |

Table S4: Recall results averaged over entire streams. Stream groups are denoted as follows: S - Single difficulty, C - Combined difficulties, N - No drift, D - Drift.

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Borderline100 | SD | 0.988 | 0.983 | 0.983 | 0.981 | 0.977 |
| Borderline100 (static) | SN | 0.991 | 0.993 | 0.993 | 0.993 | 0.992 |
| Borderline20 | SD | 0.990 | 0.984 | 0.984 | 0.984 | 0.980 |
| Borderline20 + Rare20 | SN | 0.881 | 0.869 | 0.867 | 0.868 | 0.867 |
| Borderline20 + Rare20 (static) | CD | 0.807 | 0.795 | 0.791 | 0.794 | 0.795 |
| Borderline20 (static) | CN | 0.990 | 0.990 | 0.989 | 0.988 | 0.987 |
| Borderline40 | SD | 0.989 | 0.984 | 0.983 | 0.982 | 0.979 |
| Borderline40 + Rare40 | SN | 0.758 | 0.737 | 0.736 | 0.736 | 0.736 |
| Borderline40 + Rare40 (static) | CD | 0.630 | 0.605 | 0.604 | 0.606 | 0.611 |
| Borderline40 (static) | CN | 0.990 | 0.990 | 0.990 | 0.990 | 0.988 |
| Borderline60 | SD | 0.988 | 0.983 | 0.983 | 0.982 | 0.978 |
| Borderline60 (static) | SN | 0.990 | 0.991 | 0.991 | 0.991 | 0.989 |
| Borderline80 | SD | 0.987 | 0.982 | 0.983 | 0.981 | 0.979 |
| Borderline80 (static) | SN | 0.991 | 0.992 | 0.992 | 0.991 | 0.990 |
| Im1 | SD | 0.992 | 0.985 | 0.990 | 0.997 | 0.981 |
| Im1 + Borderline100 | SN | 0.945 | 0.879 | 0.947 | 0.969 | 0.861 |
| Im1 + Borderline100 (static) | CD | 0.745 | 0.000 | 0.701 | 0.977 | 0.004 |
| Im1 + Borderline20 | CN | 0.983 | 0.937 | 0.954 | 0.973 | 0.935 |
| Im1 + Borderline20 + Rare20 | CD | 0.854 | 0.828 | 0.846 | 0.864 | 0.830 |
| Im1 + Borderline20 + Rare20 (static) | CN | 0.732 | 0.009 | 0.606 | 0.818 | 0.090 |
| Im1 + Borderline20 (static) | CD | 0.907 | 0.178 | 0.811 | 0.976 | 0.251 |
| Im1 + Borderline40 | CN | 0.971 | 0.894 | 0.928 | 0.953 | 0.885 |
| Im1 + Borderline40 + Rare40 | CD | 0.709 | 0.677 | 0.704 | 0.726 | 0.680 |
| Im1 + Borderline40 + Rare40 (static) | CN | 0.551 | 0.000 | 0.246 | 0.710 | 0.015 |
| Im1 + Borderline40 (static) | CD | 0.857 | 0.045 | 0.756 | 0.974 | 0.100 |
| Im1 + Borderline60 | CN | 0.964 | 0.871 | 0.926 | 0.963 | 0.868 |
| Im1 + Borderline60 (static) | CD | 0.829 | 0.000 | 0.750 | 0.974 | 0.023 |
| Im1 + Borderline80 | CN | 0.952 | 0.866 | 0.933 | 0.967 | 0.855 |
| Im1 + Borderline80 (static) | CD | 0.777 | 0.000 | 0.695 | 0.979 | 0.010 |
| Im1 + Rare100 | CN | 0.389 | 0.355 | 0.384 | 0.612 | 0.389 |
| Im1 + Rare100 (static) | CD | 0.342 | 0.000 | 0.012 | 0.678 | 0.028 |
| Im1 + Rare20 | CN | 0.856 | 0.873 | 0.875 | 0.882 | 0.872 |
| Im1 + Rare20 (static) | CD | 0.776 | 0.107 | 0.722 | 0.812 | 0.164 |
| Im1 + Rare40 | CN | 0.744 | 0.762 | 0.770 | 0.771 | 0.769 |
| Im1 + Rare40 (static) | CD | 0.632 | 0.025 | 0.490 | 0.714 | 0.098 |
| Im1 + Rare60 | CN | 0.618 | 0.652 | 0.655 | 0.656 | 0.669 |
| Im1 + Rare60 (static) | CD | 0.548 | 0.001 | 0.297 | 0.616 | 0.031 |
| Im1 + Rare80 | CN | 0.421 | 0.515 | 0.522 | 0.519 | 0.532 |
| Im1 + Rare80 (static) | CD | 0.163 | 0.000 | 0.054 | 0.585 | 0.028 |
| Im1 (static) | CN | 0.977 | 0.336 | 0.898 | 0.993 | 0.381 |
| Im10 | SD | 0.992 | 0.990 | 0.995 | 0.997 | 0.986 |
| Im10 + Borderline100 | SN | 0.971 | 0.943 | 0.975 | 0.976 | 0.922 |
| Im10 + Borderline100 (static) | CD | 0.991 | 0.890 | 0.978 | 0.992 | 0.871 |
| Im10 + Borderline20 | CN | 0.986 | 0.952 | 0.975 | 0.980 | 0.948 |
| Im10 + Borderline20 + Rare20 | CD | 0.870 | 0.838 | 0.859 | 0.860 | 0.835 |
| Im10 + Borderline20 + Rare20 (static) | CN | 0.801 | 0.706 | 0.780 | 0.797 | 0.701 |
| Im10 + Borderline20 (static) | CD | 0.989 | 0.891 | 0.971 | 0.986 | 0.894 |
| Im10 + Borderline40 | CN | 0.981 | 0.937 | 0.974 | 0.974 | 0.932 |
| Im10 + Borderline40 + Rare40 | CD | 0.745 | 0.695 | 0.732 | 0.733 | 0.694 |
| Im10 + Borderline40 + Rare40 (static) | CN | 0.643 | 0.473 | 0.591 | 0.635 | 0.472 |
| Im10 + Borderline40 (static) | CD | 0.990 | 0.866 | 0.972 | 0.988 | 0.878 |
| Im10 + Borderline60 | CN | 0.977 | 0.932 | 0.973 | 0.974 | 0.925 |
| Im10 + Borderline60 (static) | CD | 0.989 | 0.873 | 0.977 | 0.990 | 0.850 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Im10 + Borderline80 | CN | 0.974 | 0.936 | 0.974 | 0.974 | 0.921 |
| Im10 + Borderline80 (static) | CD | 0.989 | 0.881 | 0.977 | 0.989 | 0.848 |
| Im10 + Rare100 | CN | 0.514 | 0.359 | 0.407 | 0.635 | 0.374 |
| Im10 + Rare100 (static) | CD | 0.547 | 0.000 | 0.024 | 0.676 | 0.015 |
| Im10 + Rare20 | CN | 0.880 | 0.875 | 0.880 | 0.883 | 0.876 |
| Im10 + Rare20 (static) | CD | 0.801 | 0.768 | 0.790 | 0.802 | 0.755 |
| Im10 + Rare40 | CN | 0.766 | 0.759 | 0.763 | 0.765 | 0.761 |
| Im10 + Rare40 (static) | CD | 0.627 | 0.563 | 0.599 | 0.618 | 0.571 |
| Im10 + Rare60 | CN | 0.650 | 0.637 | 0.640 | 0.642 | 0.641 |
| Im10 + Rare60 (static) | CD | 0.569 | 0.330 | 0.398 | 0.452 | 0.354 |
| Im10 + Rare80 | CN | 0.548 | 0.509 | 0.515 | 0.519 | 0.514 |
| Im10 + Rare80 (static) | CD | 0.582 | 0.107 | 0.210 | 0.417 | 0.121 |
| Im10 (static) | CN | 0.993 | 0.964 | 0.989 | 0.996 | 0.962 |
| Im2 | SD | 0.984 | 0.994 | 0.997 | 0.999 | 0.976 |
| Im20 | SD | 0.991 | 0.998 | 0.999 | 0.999 | 0.993 |
| Im3 | SD | 0.984 | 0.995 | 0.997 | 0.999 | 0.979 |
| Im30 | SD | 0.992 | 0.999 | 0.999 | 0.999 | 0.996 |
| Im40 | SD | 0.992 | 0.999 | 0.999 | 0.999 | 0.997 |
| Im5 | SD | 0.986 | 0.997 | 0.998 | 0.999 | 0.988 |
| Merge3 | SD | 0.976 | 0.990 | 0.991 | 0.991 | 0.987 |
| Merge3 (static) | SN | 0.993 | 0.998 | 0.998 | 0.998 | 0.997 |
| Merge5 | SD | 0.985 | 0.988 | 0.990 | 0.989 | 0.985 |
| Merge5 (static) | SN | 0.992 | 0.995 | 0.995 | 0.995 | 0.994 |
| Merge7 | SD | 0.992 | 0.991 | 0.991 | 0.990 | 0.987 |
| Merge7 (static) | SN | 0.992 | 0.999 | 0.999 | 0.999 | 0.997 |
| Move3 | SD | 0.978 | 0.987 | 0.989 | 0.989 | 0.980 |
| Move3 (static) | SN | 0.992 | 0.997 | 0.997 | 0.996 | 0.993 |
| Move5 | SD | 0.979 | 0.987 | 0.990 | 0.986 | 0.982 |
| Move5 (static) | SN | 0.990 | 0.996 | 0.996 | 0.995 | 0.994 |
| Move7 | SD | 0.961 | 0.970 | 0.971 | 0.966 | 0.963 |
| Move7 (static) | SN | 0.992 | 0.993 | 0.994 | 0.992 | 0.984 |
| Rare100 | SD | 0.674 | 0.633 | 0.650 | 0.624 | 0.686 |
| Rare100 (static) | SN | 0.593 | 0.572 | 0.568 | 0.573 | 0.613 |
| Rare20 | SD | 0.881 | 0.882 | 0.882 | 0.882 | 0.882 |
| Rare20 (static) | SN | 0.804 | 0.801 | 0.802 | 0.802 | 0.802 |
| Rare40 | SD | 0.768 | 0.764 | 0.764 | 0.762 | 0.766 |
| Rare40 (static) | SN | 0.624 | 0.604 | 0.603 | 0.605 | 0.612 |
| Rare60 | SD | 0.654 | 0.641 | 0.642 | 0.641 | 0.653 |
| Rare60 (static) | SN | 0.464 | 0.417 | 0.416 | 0.419 | 0.449 |
| Rare80 | SD | 0.631 | 0.538 | 0.547 | 0.532 | 0.572 |
| Rare80 (static) | SN | 0.411 | 0.316 | 0.324 | 0.306 | 0.370 |
| Split3 | SD | 0.978 | 0.985 | 0.986 | 0.984 | 0.982 |
| Split3 (static) | SN | 0.992 | 0.998 | 0.998 | 0.998 | 0.996 |
| Split5 | SD | 0.919 | 0.975 | 0.977 | 0.970 | 0.968 |
| Split5 + Borderline100 | SN | 0.779 | 0.920 | 0.925 | 0.912 | 0.904 |
| Split5 + Borderline100 (static) | CD | 0.965 | 0.972 | 0.973 | 0.972 | 0.963 |
| Split5 + Borderline20 | CN | 0.895 | 0.949 | 0.951 | 0.943 | 0.942 |
| Split5 + Borderline20 + Rare20 | CD | 0.820 | 0.846 | 0.848 | 0.839 | 0.842 |
| Split5 + Borderline20 + Rare20 (static) | CN | 0.801 | 0.765 | 0.765 | 0.764 | 0.765 |
| Split5 + Borderline20 (static) | CD | 0.973 | 0.954 | 0.952 | 0.953 | 0.947 |
| Split5 + Borderline40 | CN | 0.893 | 0.946 | 0.950 | 0.939 | 0.938 |
| Split5 + Borderline40 + Rare40 | CD | 0.779 | 0.719 | 0.722 | 0.709 | 0.724 |
| Split5 + Borderline40 + Rare40 (static) | CN | 0.642 | 0.586 | 0.587 | 0.589 | 0.587 |
| Split5 + Borderline40 (static) | CD | 0.963 | 0.952 | 0.952 | 0.954 | 0.945 |
| Split5 + Borderline60 | CN | 0.896 | 0.941 | 0.944 | 0.935 | 0.935 |
| Split5 + Borderline60 (static) | CD | 0.960 | 0.959 | 0.962 | 0.958 | 0.944 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Split5 + Borderline80 | CN | 0.939 | 0.926 | 0.930 | 0.919 | 0.910 |
| Split5 + Borderline80 (static) | CD | 0.964 | 0.967 | 0.966 | 0.961 | 0.949 |
| Split5 + Im1 | CN | 0.699 | 0.665 | 0.817 | 0.903 | 0.662 |
| Split5 + Im1 + Borderline100 | CD | 0.557 | 0.515 | 0.647 | 0.811 | 0.524 |
| Split5 + Im1 + Borderline100 (static) | CN | 0.190 | 0.000 | 0.017 | 0.849 | 0.001 |
| Split5 + Im1 + Borderline20 | CD | 0.629 | 0.576 | 0.739 | 0.821 | 0.597 |
| Split5 + Im1 + Borderline20 + Rare20 | CN | 0.562 | 0.515 | 0.628 | 0.768 | 0.524 |
| Split5 + Im1 + Borderline20 + Rare20 (static) | CD | 0.371 | 0.000 | 0.237 | 0.798 | 0.007 |
| Split5 + Im1 + Borderline20 (static) | CN | 0.590 | 0.000 | 0.320 | 0.919 | 0.001 |
| Split5 + Im1 + Borderline40 | CD | 0.631 | 0.572 | 0.712 | 0.814 | 0.581 |
| Split5 + Im1 + Borderline40 + Rare40 | CN | 0.437 | 0.437 | 0.491 | 0.636 | 0.456 |
| Split5 + Im1 + Borderline40 + Rare40 (static) | CD | 0.282 | 0.000 | 0.011 | 0.695 | 0.013 |
| Split5 + Im1 + Borderline40 (static) | CN | 0.570 | 0.000 | 0.294 | 0.892 | 0.001 |
| Split5 + Im1 + Borderline60 | CD | 0.548 | 0.533 | 0.666 | 0.797 | 0.540 |
| Split5 + Im1 + Borderline60 (static) | CN | 0.439 | 0.000 | 0.139 | 0.879 | 0.002 |
| Split5 + Im1 + Borderline80 | CD | 0.530 | 0.495 | 0.646 | 0.790 | 0.500 |
| Split5 + Im1 + Borderline80 (static) | CN | 0.200 | 0.000 | 0.067 | 0.859 | 0.000 |
| Split5 + Im1 + Rare100 | CD | 0.424 | 0.359 | 0.397 | 0.599 | 0.402 |
| Split5 + Im1 + Rare100 (static) | CN | 0.354 | 0.000 | 0.017 | 0.601 | 0.033 |
| Split5 + Im1 + Rare20 | CD | 0.596 | 0.561 | 0.711 | 0.820 | 0.588 |
| Split5 + Im1 + Rare20 (static) | CN | 0.414 | 0.000 | 0.300 | 0.809 | 0.015 |
| Split5 + Im1 + Rare40 | CD | 0.478 | 0.551 | 0.605 | 0.726 | 0.564 |
| Split5 + Im1 + Rare40 (static) | CN | 0.361 | 0.000 | 0.237 | 0.703 | 0.021 |
| Split5 + Im1 + Rare60 | CD | 0.461 | 0.424 | 0.482 | 0.553 | 0.439 |
| Split5 + Im1 + Rare60 (static) | CN | 0.195 | 0.000 | 0.061 | 0.609 | 0.027 |
| Split5 + Im1 + Rare80 | CD | 0.413 | 0.398 | 0.431 | 0.482 | 0.427 |
| Split5 + Im1 + Rare80 (static) | CN | 0.153 | 0.000 | 0.011 | 0.638 | 0.024 |
| Split5 + Im1 (static) | CD | 0.661 | 0.000 | 0.548 | 0.945 | 0.015 |
| Split5 + Im10 | CN | 0.785 | 0.856 | 0.958 | 0.947 | 0.850 |
| Split5 + Im10 + Borderline100 | CD | 0.716 | 0.632 | 0.895 | 0.900 | 0.658 |
| Split5 + Im10 + Borderline100 (static) | CN | 0.956 | 0.175 | 0.884 | 0.956 | 0.211 |
| Split5 + Im10 + Borderline20 | CD | 0.776 | 0.802 | 0.929 | 0.921 | 0.812 |
| Split5 + Im10 + Borderline20 + Rare20 | CN | 0.707 | 0.673 | 0.812 | 0.816 | 0.687 |
| Split5 + Im10 + Borderline20 + Rare20 (static) | CD | 0.788 | 0.395 | 0.710 | 0.769 | 0.396 |
| Split5 + Im10 + Borderline20 (static) | CN | 0.966 | 0.636 | 0.910 | 0.956 | 0.647 |
| Split5 + Im10 + Borderline40 | CD | 0.752 | 0.717 | 0.905 | 0.903 | 0.719 |
| Split5 + Im10 + Borderline40 + Rare40 | CN | 0.572 | 0.478 | 0.665 | 0.666 | 0.497 |
| Split5 + Im10 + Borderline40 + Rare40 (static) | CD | 0.652 | 0.059 | 0.460 | 0.626 | 0.105 |
| Split5 + Im10 + Borderline40 (static) | CN | 0.956 | 0.518 | 0.878 | 0.951 | 0.540 |
| Split5 + Im10 + Borderline60 | CD | 0.737 | 0.664 | 0.884 | 0.880 | 0.676 |
| Split5 + Im10 + Borderline60 (static) | CN | 0.951 | 0.410 | 0.879 | 0.956 | 0.410 |
| Split5 + Im10 + Borderline80 | CD | 0.714 | 0.619 | 0.893 | 0.888 | 0.630 |
| Split5 + Im10 + Borderline80 (static) | CN | 0.956 | 0.305 | 0.886 | 0.950 | 0.355 |
| Split5 + Im10 + Rare100 | CD | 0.519 | 0.360 | 0.419 | 0.628 | 0.374 |
| Split5 + Im10 + Rare100 (static) | CN | 0.541 | 0.000 | 0.067 | 0.648 | 0.016 |
| Split5 + Im10 + Rare20 | CD | 0.718 | 0.721 | 0.853 | 0.841 | 0.720 |
| Split5 + Im10 + Rare20 (static) | CN | 0.805 | 0.531 | 0.772 | 0.798 | 0.529 |
| Split5 + Im10 + Rare40 | CD | 0.645 | 0.622 | 0.744 | 0.738 | 0.638 |
| Split5 + Im10 + Rare40 (static) | CN | 0.639 | 0.289 | 0.585 | 0.627 | 0.334 |
| Split5 + Im10 + Rare60 | CD | 0.562 | 0.453 | 0.609 | 0.614 | 0.500 |
| Split5 + Im10 + Rare60 (static) | CN | 0.556 | 0.110 | 0.360 | 0.481 | 0.131 |
| Split5 + Im10 + Rare80 | CD | 0.529 | 0.400 | 0.476 | 0.498 | 0.414 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Split5 + Im10 + Rare80 (static) | CN | 0.550 | 0.000 | 0.147 | 0.604 | 0.014 |
| Split5 + Im10 (static) | CD | 0.992 | 0.783 | 0.979 | 0.989 | 0.789 |
| Split5 + Rare100 | CN | 0.721 | 0.684 | 0.693 | 0.669 | 0.695 |
| Split5 + Rare100 (static) | CD | 0.603 | 0.670 | 0.662 | 0.660 | 0.681 |
| Split5 + Rare20 | CN | 0.805 | 0.863 | 0.866 | 0.857 | 0.858 |
| Split5 + Rare20 (static) | CD | 0.808 | 0.800 | 0.799 | 0.799 | 0.794 |
| Split5 + Rare40 | CN | 0.767 | 0.750 | 0.752 | 0.749 | 0.749 |
| Split5 + Rare40 (static) | CD | 0.639 | 0.608 | 0.612 | 0.612 | 0.612 |
| Split5 + Rare60 | CN | 0.714 | 0.644 | 0.644 | 0.635 | 0.670 |
| Split5 + Rare60 (static) | CD | 0.507 | 0.440 | 0.440 | 0.441 | 0.480 |
| Split5 + Rare80 | CN | 0.707 | 0.603 | 0.603 | 0.591 | 0.634 |
| Split5 + Rare80 (static) | CD | 0.536 | 0.503 | 0.513 | 0.490 | 0.554 |
| Split5 (static) | CN | 0.992 | 0.994 | 0.996 | 0.993 | 0.988 |
| Split7 | SD | 0.947 | 0.980 | 0.980 | 0.976 | 0.973 |
| Split7 (static) | SN | 0.992 | 0.997 | 0.997 | 0.996 | 0.993 |
| StaticIm1 | SN | 0.805 | 0.008 | 0.816 | 0.989 | 0.030 |
| StaticIm10 | CD | 0.993 | 0.964 | 0.990 | 0.997 | 0.958 |
| StaticIm10 (static) | CD | 0.993 | 0.964 | 0.990 | 0.997 | 0.958 |
| StaticIm10 + Borderline100 | CD | 0.985 | 0.841 | 0.964 | 0.983 | 0.837 |
| StaticIm10 + Borderline100 (static) | CD | 0.991 | 0.891 | 0.980 | 0.993 | 0.869 |
| StaticIm10 + Borderline20 | CD | 0.990 | 0.919 | 0.964 | 0.987 | 0.909 |
| StaticIm10 + Borderline20 + Rare20 | CD | 0.878 | 0.804 | 0.847 | 0.870 | 0.797 |
| StaticIm10 + Borderline20 + Rare20 (static) | CN | 0.801 | 0.707 | 0.781 | 0.794 | 0.700 |
| StaticIm10 + Borderline20 (static) | CD | 0.989 | 0.893 | 0.971 | 0.987 | 0.894 |
| StaticIm10 + Borderline40 | CN | 0.987 | 0.893 | 0.961 | 0.984 | 0.881 |
| StaticIm10 + Borderline40 + Rare40 | CD | 0.762 | 0.644 | 0.722 | 0.746 | 0.636 |
| StaticIm10 + Borderline40 + Rare40 (static) | CN | 0.643 | 0.473 | 0.591 | 0.636 | 0.447 |
| StaticIm10 + Borderline40 (static) | CD | 0.989 | 0.876 | 0.976 | 0.989 | 0.878 |
| StaticIm10 + Borderline60 | CN | 0.986 | 0.871 | 0.961 | 0.983 | 0.859 |
| StaticIm10 + Borderline60 (static) | CD | 0.990 | 0.866 | 0.976 | 0.989 | 0.851 |
| StaticIm10 + Borderline80 | CN | 0.986 | 0.852 | 0.961 | 0.983 | 0.843 |
| StaticIm10 + Borderline80 (static) | CD | 0.990 | 0.877 | 0.977 | 0.990 | 0.849 |
| StaticIm10 + Im1 | CN | 0.993 | 0.910 | 0.978 | 0.998 | 0.848 |
| StaticIm10 + Im1 + Borderline100 | CD | 0.975 | 0.582 | 0.908 | 0.977 | 0.628 |
| StaticIm10 + Im1 + Borderline100 (static) | CN | 0.736 | 0.000 | 0.689 | 0.978 | 0.013 |
| StaticIm10 + Im1 + Borderline20 | CD | 0.985 | 0.835 | 0.927 | 0.984 | 0.802 |
| StaticIm10 + Im1 + Borderline20 + Rare20 | CN | 0.860 | 0.717 | 0.822 | 0.872 | 0.732 |
| StaticIm10 + Im1 + Borderline20 + Rare20 (static) | CD | 0.729 | 0.031 | 0.621 | 0.823 | 0.099 |
| StaticIm10 + Im1 + Borderline20 (static) | CN | 0.900 | 0.184 | 0.805 | 0.977 | 0.251 |
| StaticIm10 + Im1 + Borderline40 | SN | 0.980 | 0.757 | 0.892 | 0.976 | 0.728 |
| StaticIm10 + Im1 + Borderline40 + Rare40 | SN | 0.743 | 0.533 | 0.665 | 0.747 | 0.570 |
| StaticIm10 + Im1 + Borderline40 + Rare40 (static) | CD | 0.549 | 0.000 | 0.307 | 0.720 | 0.014 |
| StaticIm10 + Im1 + Borderline40 (static) | CN | 0.847 | 0.015 | 0.751 | 0.974 | 0.097 |
| StaticIm10 + Im1 + Borderline60 | CD | 0.980 | 0.686 | 0.886 | 0.973 | 0.756 |
| StaticIm10 + Im1 + Borderline60 (static) | CN | 0.807 | 0.000 | 0.731 | 0.976 | 0.015 |
| StaticIm10 + Im1 + Borderline80 | CD | 0.971 | 0.614 | 0.892 | 0.972 | 0.620 |
| StaticIm10 + Im1 + Borderline80 (static) | CN | 0.768 | 0.000 | 0.645 | 0.980 | 0.004 |
| StaticIm10 + Im1 + Rare100 | CD | 0.596 | 0.336 | 0.357 | 0.354 | 0.357 |
| StaticIm10 + Im1 + Rare100 (static) | CN | 0.354 | 0.000 | 0.016 | 0.593 | 0.031 |
| StaticIm10 + Im1 + Rare20 | CD | 0.876 | 0.783 | 0.863 | 0.880 | 0.747 |
| StaticIm10 + Im1 + Rare20 (static) | CN | 0.787 | 0.162 | 0.699 | 0.815 | 0.230 |
| StaticIm10 + Im1 + Rare40 | CD | 0.754 | 0.673 | 0.749 | 0.763 | 0.639 |
| StaticIm10 + Im1 + Rare40 (static) | CN | 0.617 | 0.027 | 0.490 | 0.712 | 0.061 |
| StaticIm10 + Im1 + Rare60 | CD | 0.708 | 0.567 | 0.647 | 0.654 | 0.560 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm10 + Im1 + Rare60 (static) | CN | 0.523 | 0.002 | 0.256 | 0.600 | 0.034 |
| StaticIm10 + Im1 + Rare80 | CD | 0.597 | 0.464 | 0.517 | 0.525 | 0.487 |
| StaticIm10 + Im1 + Rare80 (static) | CN | 0.143 | 0.000 | 0.070 | 0.633 | 0.026 |
| StaticIm10 + Im1 (static) | CD | 0.976 | 0.344 | 0.898 | 0.994 | 0.376 |
| StaticIm10 + Im2 | CN | 0.991 | 0.835 | 0.994 | 0.999 | 0.854 |
| StaticIm10 + Im3 | CD | 0.992 | 0.878 | 0.995 | 0.999 | 0.878 |
| StaticIm10 + Im5 | CN | 0.992 | 0.918 | 0.996 | 0.999 | 0.914 |
| StaticIm10 + Im60 | CD | 0.992 | 0.966 | 0.998 | 0.999 | 0.960 |
| StaticIm10 + Im70 | CN | 0.992 | 0.967 | 0.998 | 0.999 | 0.960 |
| StaticIm10 + Im80 | CD | 0.992 | 0.967 | 0.998 | 0.999 | 0.961 |
| StaticIm10 + Im90 | CN | 0.992 | 0.967 | 0.998 | 0.999 | 0.961 |
| StaticIm10 + Merge3 | CD | 0.988 | 0.768 | 0.973 | 0.986 | 0.766 |
| StaticIm10 + Merge3 (static) | CN | 0.993 | 0.967 | 0.992 | 0.998 | 0.964 |
| StaticIm10 + Merge5 | CD | 0.990 | 0.763 | 0.968 | 0.978 | 0.732 |
| StaticIm10 + Merge5 (static) | CN | 0.993 | 0.944 | 0.986 | 0.995 | 0.928 |
| StaticIm10 + Merge7 | CD | 0.993 | 0.768 | 0.975 | 0.986 | 0.775 |
| StaticIm10 + Merge7 (static) | CN | 0.993 | 0.980 | 0.994 | 0.998 | 0.977 |
| StaticIm10 + Move3 | CD | 0.975 | 0.690 | 0.959 | 0.978 | 0.690 |
| StaticIm10 + Move3 (static) | CN | 0.992 | 0.871 | 0.980 | 0.993 | 0.868 |
| StaticIm10 + Move5 | CD | 0.969 | 0.670 | 0.948 | 0.963 | 0.660 |
| StaticIm10 + Move5 (static) | CN | 0.990 | 0.789 | 0.980 | 0.984 | 0.784 |
| StaticIm10 + Move7 | CD | 0.978 | 0.660 | 0.948 | 0.974 | 0.679 |
| StaticIm10 + Move7 (static) | CN | 0.992 | 0.793 | 0.983 | 0.981 | 0.800 |
| StaticIm10 + Rare100 | CD | 0.706 | 0.336 | 0.370 | 0.522 | 0.343 |
| StaticIm10 + Rare100 (static) | CN | 0.520 | 0.000 | 0.026 | 0.694 | 0.016 |
| StaticIm10 + Rare20 | CD | 0.878 | 0.847 | 0.873 | 0.879 | 0.846 |
| StaticIm10 + Rare20 (static) | CN | 0.800 | 0.765 | 0.789 | 0.802 | 0.753 |
| StaticIm10 + Rare40 | CD | 0.772 | 0.732 | 0.756 | 0.763 | 0.733 |
| StaticIm10 + Rare40 (static) | CD | 0.624 | 0.563 | 0.596 | 0.619 | 0.571 |
| StaticIm10 + Rare60 | CD | 0.735 | 0.614 | 0.635 | 0.642 | 0.615 |
| StaticIm10 + Rare60 (static) | CD | 0.569 | 0.338 | 0.396 | 0.454 | 0.349 |
| StaticIm10 + Rare80 | CD | 0.707 | 0.490 | 0.514 | 0.540 | 0.492 |
| StaticIm10 + Rare80 (static) | CD | 0.575 | 0.109 | 0.206 | 0.401 | 0.120 |
| StaticIm10 + Split3 | CD | 0.986 | 0.772 | 0.956 | 0.974 | 0.773 |
| StaticIm10 + Split3 (static) | CD | 0.993 | 0.864 | 0.986 | 0.991 | 0.862 |
| StaticIm10 + Split5 | CN | 0.975 | 0.746 | 0.948 | 0.962 | 0.762 |
| StaticIm10 + Split5 + Borderline100 | CD | 0.944 | 0.446 | 0.866 | 0.923 | 0.489 |
| StaticIm10 + Split5 + Borderline100 (static) | CN | 0.955 | 0.308 | 0.898 | 0.949 | 0.339 |
| StaticIm10 + Split5 + Borderline20 | CD | 0.962 | 0.720 | 0.919 | 0.937 | 0.731 |
| StaticIm10 + Split5 + Borderline20 + Rare20 | CN | 0.866 | 0.540 | 0.791 | 0.808 | 0.564 |
| StaticIm10 + Split5 + Borderline20 + Rare20 (static) | CD | 0.790 | 0.455 | 0.718 | 0.785 | 0.490 |
| StaticIm10 + Split5 + Borderline20 (static) | CN | 0.967 | 0.698 | 0.917 | 0.961 | 0.701 |
| StaticIm10 + Split5 + Borderline40 | CD | 0.954 | 0.633 | 0.897 | 0.935 | 0.654 |
| StaticIm10 + Split5 + Borderline40 + Rare40 | CN | 0.773 | 0.380 | 0.644 | 0.679 | 0.405 |
| StaticIm10 + Split5 + Borderline40 + Rare40 (static) | CD | 0.635 | 0.122 | 0.495 | 0.618 | 0.181 |
| StaticIm10 + Split5 + Borderline40 (static) | CN | 0.955 | 0.593 | 0.896 | 0.955 | 0.629 |
| StaticIm10 + Split5 + Borderline60 | CD | 0.951 | 0.514 | 0.881 | 0.917 | 0.551 |
| StaticIm10 + Split5 + Borderline60 (static) | CN | 0.947 | 0.487 | 0.895 | 0.951 | 0.531 |
| StaticIm10 + Split5 + Borderline80 | CD | 0.955 | 0.519 | 0.871 | 0.916 | 0.541 |
| StaticIm10 + Split5 + Borderline80 (static) | CN | 0.949 | 0.406 | 0.892 | 0.952 | 0.430 |
| StaticIm10 + Split5 + Im1 | CD | 0.768 | 0.396 | 0.687 | 0.858 | 0.418 |
| StaticIm10 + Split5 + Im1 + Borderline100 | CN | 0.703 | 0.362 | 0.517 | 0.798 | 0.363 |
| StaticIm10 + Split5 + Im1 + Borderline100 (static) | CD | 0.365 | 0.000 | 0.094 | 0.895 | 0.002 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm10 + Split5 + Im1 + Borderline20 | CN | 0.769 | 0.393 | 0.669 | 0.864 | 0.413 |
| StaticIm10 + Split5 + Im1 + Borderline20 + Rare20 | CD | 0.695 | 0.391 | 0.561 | 0.734 | 0.399 |
| StaticIm10 + Split5 + Im1 + Borderline20 + Rare20 (static) | CN | 0.501 | 0.001 | 0.291 | 0.814 | 0.012 |
| StaticIm10 + Split5 + Im1 + Borderline20 (static) | CD | 0.658 | 0.000 | 0.466 | 0.923 | 0.004 |
| StaticIm10 + Split5 + Im1 + Borderline40 | CN | 0.727 | 0.388 | 0.633 | 0.793 | 0.417 |
| StaticIm10 + Split5 + Im1 + Borderline40 + Rare40 | CD | 0.575 | 0.372 | 0.457 | 0.562 | 0.382 |
| StaticIm10 + Split5 + Im1 + Borderline40 + Rare40 (static) | CN | 0.218 | 0.000 | 0.036 | 0.699 | 0.014 |
| StaticIm10 + Split5 + Im1 + Borderline40 (static) | CD | 0.539 | 0.000 | 0.339 | 0.900 | 0.001 |
| StaticIm10 + Split5 + Im1 + Borderline60 | CN | 0.711 | 0.398 | 0.578 | 0.789 | 0.412 |
| StaticIm10 + Split5 + Im1 + Borderline60 (static) | CD | 0.329 | 0.000 | 0.271 | 0.898 | 0.004 |
| StaticIm10 + Split5 + Im1 + Borderline80 | CN | 0.693 | 0.390 | 0.549 | 0.792 | 0.402 |
| StaticIm10 + Split5 + Im1 + Borderline80 (static) | CD | 0.409 | 0.000 | 0.176 | 0.892 | 0.000 |
| StaticIm10 + Split5 + Im1 + Rare100 | CN | 0.602 | 0.336 | 0.358 | 0.357 | 0.358 |
| StaticIm10 + Split5 + Im1 + Rare100 (static) | CD | 0.397 | 0.000 | 0.018 | 0.581 | 0.028 |
| StaticIm10 + Split5 + Im1 + Rare20 | CN | 0.722 | 0.391 | 0.627 | 0.754 | 0.411 |
| StaticIm10 + Split5 + Im1 + Rare20 (static) | CD | 0.599 | 0.000 | 0.404 | 0.818 | 0.005 |
| StaticIm10 + Split5 + Im1 + Rare40 | CN | 0.656 | 0.381 | 0.525 | 0.631 | 0.392 |
| StaticIm10 + Split5 + Im1 + Rare40 (static) | CD | 0.322 | 0.001 | 0.211 | 0.685 | 0.017 |
| StaticIm10 + Split5 + Im1 + Rare60 | CN | 0.594 | 0.387 | 0.479 | 0.506 | 0.394 |
| StaticIm10 + Split5 + Im1 + Rare60 (static) | CD | 0.338 | 0.001 | 0.088 | 0.615 | 0.021 |
| StaticIm10 + Split5 + Im1 + Rare80 | CN | 0.583 | 0.370 | 0.409 | 0.429 | 0.380 |
| StaticIm10 + Split5 + Im1 + Rare80 (static) | CD | 0.336 | 0.000 | 0.009 | 0.624 | 0.018 |
| StaticIm10 + Split5 + Im1 (static) | CN | 0.735 | 0.000 | 0.606 | 0.961 | 0.010 |
| StaticIm10 + Split5 + Rare100 | CD | 0.733 | 0.338 | 0.387 | 0.537 | 0.344 |
| StaticIm10 + Split5 + Rare100 (static) | CN | 0.537 | 0.000 | 0.059 | 0.682 | 0.018 |
| StaticIm10 + Split5 + Rare20 | CD | 0.875 | 0.611 | 0.833 | 0.846 | 0.624 |
| StaticIm10 + Split5 + Rare20 (static) | CN | 0.802 | 0.561 | 0.780 | 0.803 | 0.571 |
| StaticIm10 + Split5 + Rare40 | CD | 0.770 | 0.517 | 0.726 | 0.729 | 0.532 |
| StaticIm10 + Split5 + Rare40 (static) | CN | 0.643 | 0.355 | 0.581 | 0.629 | 0.370 |
| StaticIm10 + Split5 + Rare60 | CD | 0.741 | 0.419 | 0.604 | 0.630 | 0.438 |
| StaticIm10 + Split5 + Rare60 (static) | CN | 0.571 | 0.143 | 0.371 | 0.483 | 0.191 |
| StaticIm10 + Split5 + Rare80 | CD | 0.738 | 0.364 | 0.469 | 0.570 | 0.374 |
| StaticIm10 + Split5 + Rare80 (static) | CN | 0.584 | 0.002 | 0.152 | 0.590 | 0.021 |
| StaticIm10 + Split5 (static) | CD | 0.992 | 0.828 | 0.983 | 0.993 | 0.825 |
| StaticIm10 + Split7 | CN | 0.971 | 0.668 | 0.912 | 0.945 | 0.680 |
| StaticIm10 + Split7 (static) | CD | 0.991 | 0.829 | 0.985 | 0.991 | 0.830 |
| StaticIm1 + Im60 | CN | 0.929 | 0.604 | 0.889 | 0.991 | 0.611 |
| StaticIm1 + Im70 | CD | 0.934 | 0.608 | 0.889 | 0.991 | 0.614 |
| StaticIm1 + Im80 | CN | 0.931 | 0.611 | 0.889 | 0.991 | 0.616 |
| StaticIm1 + Im90 | CD | 0.932 | 0.615 | 0.889 | 0.991 | 0.620 |
| StaticIm1 + Im99 | CN | 0.924 | 0.614 | 0.889 | 0.991 | 0.622 |
| StaticIm1 + Merge3 | CD | 0.812 | 0.051 | 0.550 | 0.911 | 0.125 |
| StaticIm1 + Merge3 (static) | CN | 0.930 | 0.141 | 0.859 | 0.996 | 0.221 |
| StaticIm1 + Merge5 | CD | 0.839 | 0.126 | 0.624 | 0.960 | 0.205 |
| StaticIm1 + Merge5 (static) | CN | 0.973 | 0.301 | 0.849 | 0.994 | 0.349 |
| StaticIm1 + Merge7 | CD | 0.836 | 0.195 | 0.624 | 0.972 | 0.314 |
| StaticIm1 + Merge7 (static) | CN | 0.984 | 0.385 | 0.937 | 0.997 | 0.456 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm1 + Move3 | CD | 0.714 | 0.000 | 0.540 | 0.929 | 0.022 |
| StaticIm1 + Move3 (static) | CN | 0.745 | 0.000 | 0.595 | 0.963 | 0.003 |
| StaticIm1 + Move5 | CD | 0.684 | 0.000 | 0.495 | 0.949 | 0.007 |
| StaticIm1 + Move5 (static) | CN | 0.682 | 0.000 | 0.518 | 0.951 | 0.004 |
| StaticIm1 + Move7 | CD | 0.665 | 0.000 | 0.398 | 0.959 | 0.004 |
| StaticIm1 + Move7 (static) | CN | 0.678 | 0.000 | 0.505 | 0.911 | 0.007 |
| StaticIm1 + Split3 | CD | 0.872 | 0.089 | 0.615 | 0.878 | 0.142 |
| StaticIm1 + Split3 (static) | CN | 0.806 | 0.002 | 0.669 | 0.956 | 0.007 |
| StaticIm1 + Split5 | CD | 0.614 | 0.083 | 0.456 | 0.774 | 0.108 |
| StaticIm1 + Split5 (static) | CN | 0.639 | 0.000 | 0.456 | 0.924 | 0.006 |
| StaticIm1 + Split7 | CD | 0.783 | 0.080 | 0.519 | 0.835 | 0.134 |
| StaticIm1 + Split7 (static) | CN | 0.711 | 0.000 | 0.506 | 0.953 | 0.023 |
| StaticIm2 | SN | 0.957 | 0.229 | 0.934 | 0.996 | 0.258 |
| StaticIm20 | CD | 0.992 | 0.992 | 0.998 | 0.999 | 0.989 |
| StaticIm20 + Im1 | CD | 0.987 | 0.911 | 0.992 | 0.998 | 0.953 |
| StaticIm20 + Im10 | CD | 0.992 | 0.985 | 0.997 | 0.999 | 0.983 |
| StaticIm20 + Im2 | CD | 0.990 | 0.947 | 0.995 | 0.998 | 0.964 |
| StaticIm20 + Im3 | CD | 0.991 | 0.955 | 0.996 | 0.998 | 0.970 |
| StaticIm20 + Im5 | CD | 0.992 | 0.972 | 0.996 | 0.999 | 0.975 |
| StaticIm20 + Im60 | SD | 0.992 | 0.994 | 0.999 | 0.999 | 0.993 |
| StaticIm20 + Im70 | CD | 0.992 | 0.994 | 0.999 | 0.999 | 0.993 |
| StaticIm20 + Im80 | CD | 0.992 | 0.994 | 0.999 | 0.999 | 0.994 |
| StaticIm20 + Im90 | CD | 0.992 | 0.994 | 0.999 | 0.999 | 0.994 |
| StaticIm2 + Im1 | CD | 0.935 | 0.049 | 0.908 | 0.997 | 0.111 |
| StaticIm2 + Im60 | CD | 0.980 | 0.643 | 0.960 | 0.996 | 0.669 |
| StaticIm2 + Im70 | CD | 0.980 | 0.646 | 0.960 | 0.996 | 0.672 |
| StaticIm2 + Im80 | CD | 0.979 | 0.647 | 0.960 | 0.996 | 0.674 |
| StaticIm2 + Im90 | CD | 0.980 | 0.649 | 0.960 | 0.997 | 0.676 |
| StaticIm2 + Im98 | CD | 0.979 | 0.651 | 0.960 | 0.997 | 0.678 |
| StaticIm3 | SN | 0.983 | 0.481 | 0.974 | 0.996 | 0.508 |
| StaticIm30 | CD | 0.992 | 0.997 | 0.999 | 0.999 | 0.993 |
| StaticIm30 + Im1 | CD | 0.983 | 0.975 | 0.993 | 0.999 | 0.933 |
| StaticIm30 + Im10 | CD | 0.990 | 0.991 | 0.998 | 0.999 | 0.982 |
| StaticIm30 + Im2 | CD | 0.986 | 0.980 | 0.996 | 0.999 | 0.957 |
| StaticIm30 + Im20 | CD | 0.992 | 0.994 | 0.999 | 0.999 | 0.989 |
| StaticIm30 + Im3 | CD | 0.987 | 0.983 | 0.997 | 0.999 | 0.965 |
| StaticIm30 + Im5 | CD | 0.988 | 0.986 | 0.998 | 0.999 | 0.975 |
| StaticIm30 + Im60 | SN | 0.992 | 0.998 | 0.999 | 0.999 | 0.995 |
| StaticIm30 + Im70 | CD | 0.992 | 0.998 | 0.999 | 0.999 | 0.996 |
| StaticIm30 + Im80 | CD | 0.992 | 0.998 | 0.999 | 0.999 | 0.996 |
| StaticIm30 + Im90 | CD | 0.992 | 0.998 | 0.999 | 0.999 | 0.996 |
| StaticIm3 + Im1 | CD | 0.967 | 0.182 | 0.958 | 0.996 | 0.267 |
| StaticIm3 + Im2 | CD | 0.983 | 0.340 | 0.968 | 0.996 | 0.400 |
| StaticIm3 + Im60 | CD | 0.990 | 0.715 | 0.983 | 0.996 | 0.742 |
| StaticIm3 + Im70 | CD | 0.990 | 0.716 | 0.983 | 0.996 | 0.744 |
| StaticIm3 + Im80 | CD | 0.990 | 0.717 | 0.983 | 0.996 | 0.745 |
| StaticIm3 + Im90 | CD | 0.990 | 0.717 | 0.983 | 0.996 | 0.746 |
| StaticIm3 + Im97 | CD | 0.989 | 0.719 | 0.983 | 0.996 | 0.746 |
| StaticIm40 | SN | 0.990 | 0.999 | 0.999 | 0.999 | 0.995 |
| StaticIm40 + Im1 | CD | 0.950 | 0.982 | 0.995 | 0.999 | 0.973 |
| StaticIm40 + Im10 | CD | 0.982 | 0.995 | 0.998 | 0.999 | 0.988 |
| StaticIm40 + Im2 | CD | 0.974 | 0.990 | 0.995 | 0.999 | 0.982 |
| StaticIm40 + Im20 | CD | 0.988 | 0.997 | 0.999 | 0.999 | 0.992 |
| StaticIm40 + Im3 | CD | 0.976 | 0.993 | 0.998 | 0.999 | 0.985 |
| StaticIm40 + Im30 | CD | 0.989 | 0.999 | 0.999 | 0.999 | 0.994 |
| StaticIm40 + Im5 | CD | 0.980 | 0.994 | 0.998 | 0.999 | 0.986 |

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**Table S4 – continued from previous page**

| Experiment | Group | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| StaticIm40 + Im60 | CD | 0.992 | 0.999 | 0.999 | 0.999 | 0.997 |
| StaticIm40 + Im70 | CD | 0.992 | 0.999 | 0.999 | 0.999 | 0.997 |
| StaticIm40 + Im80 | CD | 0.992 | 0.999 | 0.999 | 0.999 | 0.998 |
| StaticIm40 + Im90 | CD | 0.992 | 0.999 | 0.999 | 0.999 | 0.998 |
| StaticIm5 | SN | 0.992 | 0.791 | 0.990 | 0.998 | 0.794 |
| StaticIm50 | CD | 0.992 | 0.999 | 0.999 | 0.999 | 0.997 |
| StaticIm5 + Im1 | CD | 0.986 | 0.399 | 0.973 | 0.998 | 0.381 |
| StaticIm5 + Im2 | CD | 0.990 | 0.587 | 0.986 | 0.998 | 0.571 |
| StaticIm5 + Im3 | CD | 0.991 | 0.701 | 0.988 | 0.998 | 0.715 |
| StaticIm5 + Im60 | CD | 0.992 | 0.863 | 0.995 | 0.998 | 0.874 |
| StaticIm5 + Im70 | CD | 0.992 | 0.863 | 0.995 | 0.998 | 0.873 |
| StaticIm5 + Im80 | CD | 0.992 | 0.864 | 0.995 | 0.998 | 0.875 |
| StaticIm5 + Im90 | CD | 0.992 | 0.864 | 0.995 | 0.998 | 0.875 |
| StaticIm5 + Im95 | SD | 0.992 | 0.864 | 0.995 | 0.998 | 0.876 |

## D Additional results for pairs of elements in the streams

Table S5: G-mean of classifiers on data streams with various imbalance ratios paired with other difficulty factors. The Moment column indicates classifier performance before the drift (pre), after the drift (post), and at the end of the stream (end).

| Configuration | Moment | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| Static minority ratio 10% with 5 moving sub-clusters | pre | 0.987 | 0.971 | 0.96 | 0.781 | 0.900 |
| | post | 0.930 | 0.938 | 0.87 | 0.845 | 0.911 |
| | end | 0.971 | 0.961 | 0.879 | 0.888 | 0.925 |
| Static minority ratio 1% with 5 moving sub-clusters | pre | 0.691 | 0.905 | 0.000 | 0.000 | 0.900 |
| | post | 0.690 | 0.893 | 0.000 | 0.000 | 0.770 |
| | end | 0.865 | 0.941 | 0.014 | 0.010 | 0.780 |
| Static minority ratio 10% with split into 5 sub-clusters | pre | 0.988 | 0.971 | 0.956 | 0.976 | 0.968 |
| | post | 0.887 | 0.874 | 0.612 | 0.660 | 0.908 |
| | end | 0.970 | 0.959 | 0.868 | 0.871 | 0.929 |
| Static minority ratio 10% with 40% rare cases | pre | 0.988 | 0.971 | 0.956 | 0.976 | 0.968 |
| | post | 0.825 | 0.880 | 0.816 | 0.810 | 0.808 |
| | end | 0.761 | 0.759 | 0.761 | 0.749 | 0.744 |
| Static minority ratio 10% with 40% borderline examples | pre | 0.988 | 0.971 | 0.956 | 0.976 | 0.968 |
| | post | 0.945 | 0.967 | 0.922 | 0.913 | 0.964 |
| | end | 0.966 | 0.965 | 0.912 | 0.897 | 0.960 |
| Drifting minority class ratio from 50% to 10% with 40% borderline cases | pre | 0.989 | 0.988 | 0.988 | 0.981 | 0.968 |
| | post | 0.959 | 0.960 | 0.954 | 0.951 | 0.963 |
| | end | 0.960 | 0.967 | 0.927 | 0.921 | 0.961 |
| Drifting minority class ratio from 50% to 1% with split into 5 sub-clusters | pre | 0.989 | 0.988 | 0.988 | 0.981 | 0.968 |
| | post | 0.912 | 0.892 | 0.854 | 0.850 | 0.855 |
| | end | 0.774 | 0.919 | 0.539 | 0.547 | 0.613 |

## E Real-world datasets

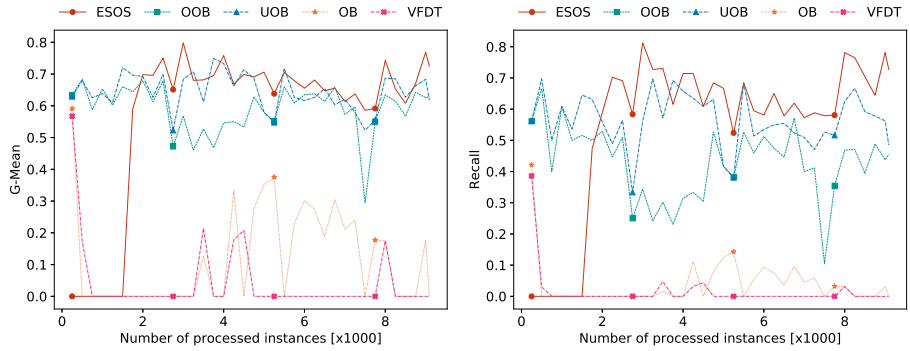



Fig. S2: Classifier G-mean (left) and Recall (right) values for the `Twitter` data stream.

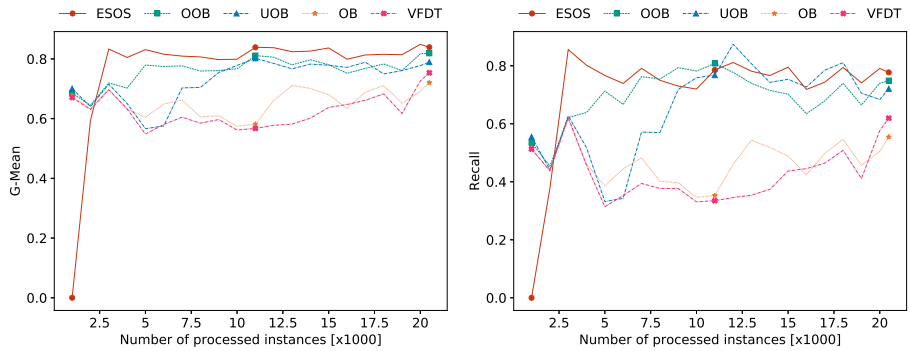



Fig. S3: Classifier G-mean (left) and Recall (right) values for the `Tripadvisor` data stream.

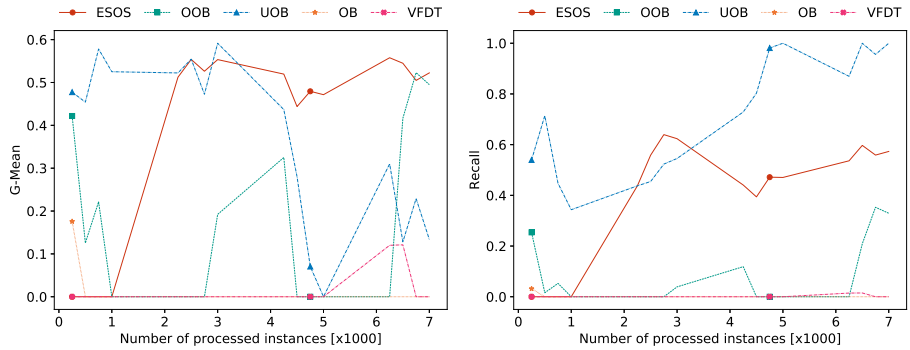



Fig. S4: Classifier G-mean (left) and Recall (right) values for the `Amazon` data stream.

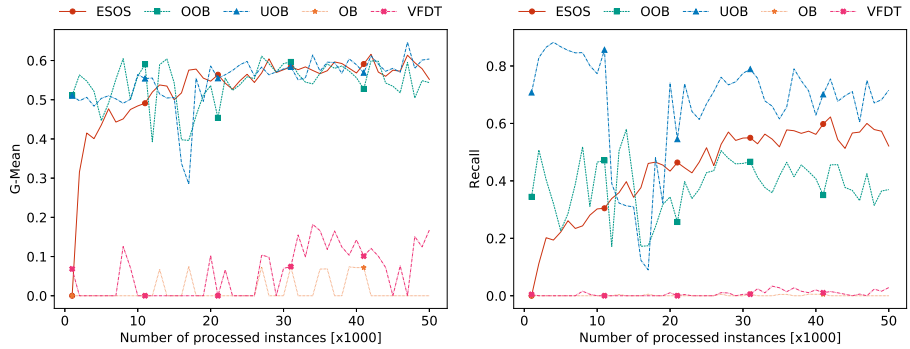
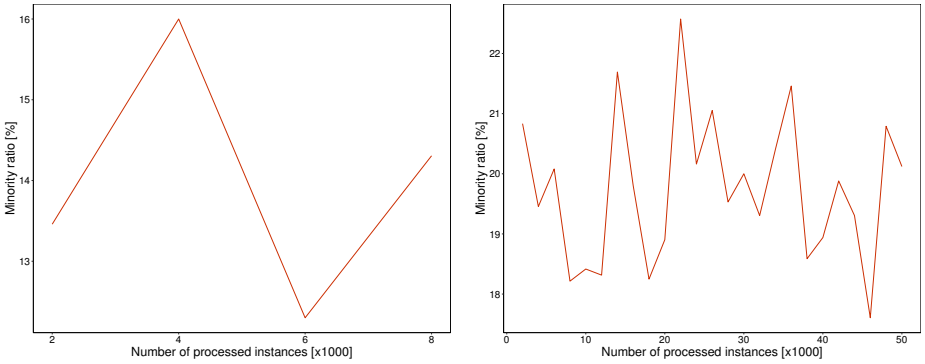



Fig. S5: Classifier G-mean (left) and Recall (right) values for the `PAKDD` data stream.

Table S6: Average classifier performance values on the real-world data streams.

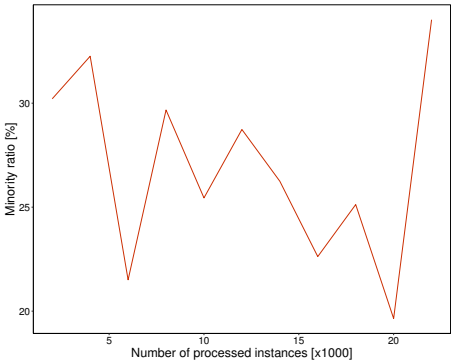
| Data stream | Metric | OOB | UOB | OB | VFDT | ESOS |
|---|---|---|---|---|---|---|
| `Amazon` | Recall | 0.086 | 0.708 | 0.002 | 0.002 | 0.391 |
| `PAKDD` | | 0.386 | 0.663 | 0.001 | 0.007 | 0.444 |
| `Tripadvisor` | | 0.699 | 0.658 | 0.468 | 0.431 | 0.716 |
| `Twitter` | | 0.435 | 0.574 | 0.040 | 0.019 | 0.561 |
| `Amazon` | G-mean | 0.241 | 0.394 | 0.021 | 0.021 | 0.402 |
| `PAKDD` | | 0.542 | 0.549 | 0.013 | 0.059 | 0.530 |
| `Tripadvisor` | | 0.764 | 0.731 | 0.656 | 0.627 | 0.771 |
| `Twitter` | | 0.600 | 0.654 | 0.155 | 0.075 | 0.598 |



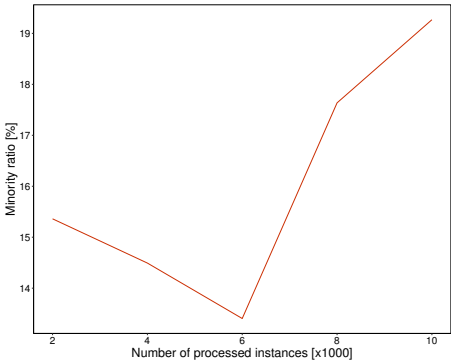

(a) `Amazon`




(b) `PAKDD`

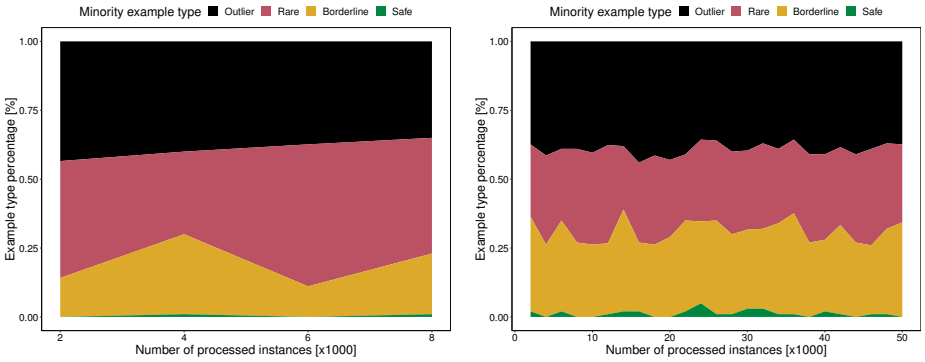



(c) `Tripadvisor`




(d) `Twitter`

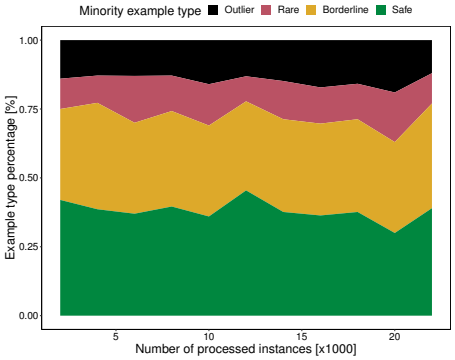
Fig. S6: Minority ratio over time for real-world datasets.



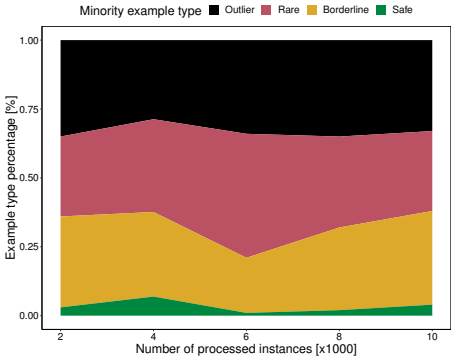

(a) `Amazon`




(b) `PAKDD`

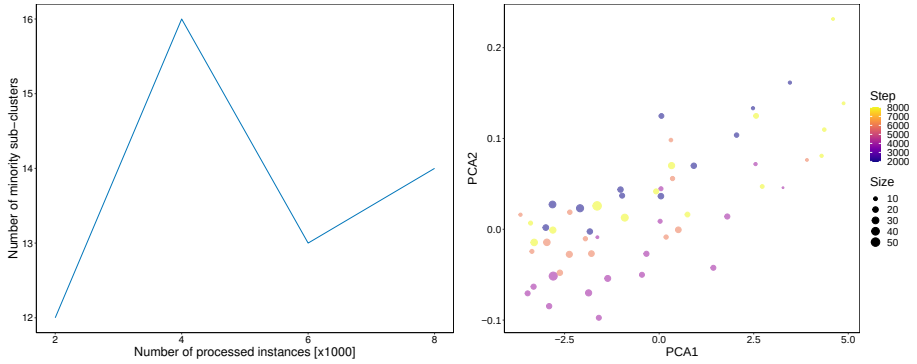



(c) `Tripadvisor`

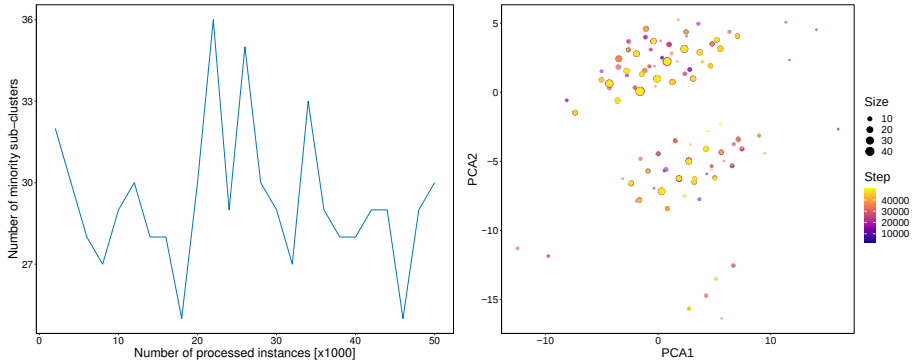



(d) `Twitter`

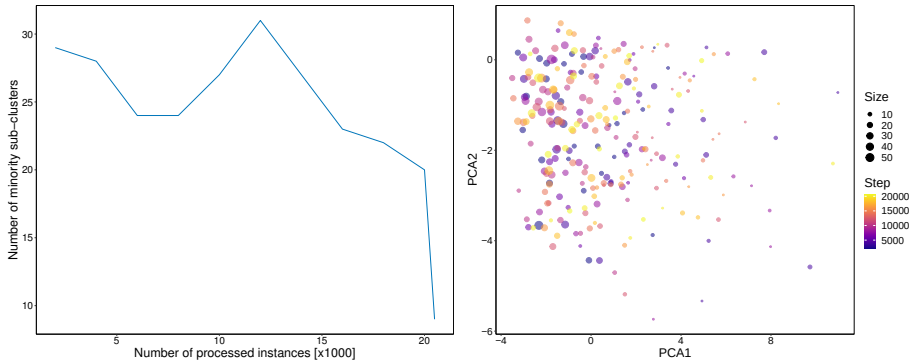
Fig. S7: Minority example type percentages over time for real-world datasets.



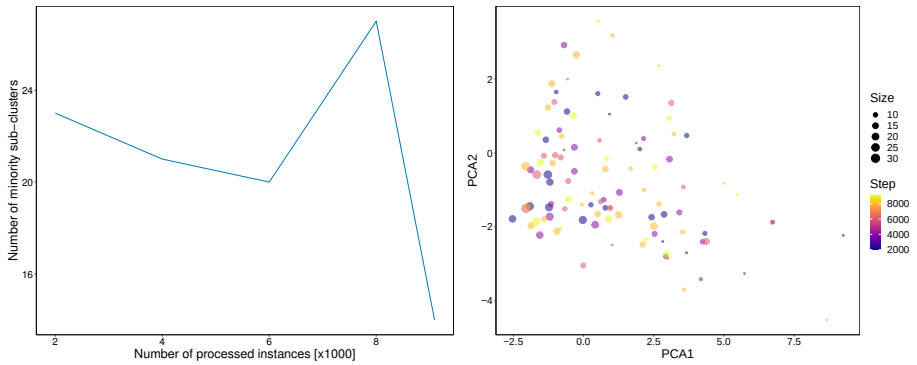

(a) `Amazon`




(b) `PAKDD`




(c) `Tripadvisor`




(d) `Twitter`

Fig. S8: Minority class composition for real-world datasets, calculated over consecutive blocks of 2000 examples. Left plots present the number of minority class clusters with more than five examples, estimated using affinity propagation algorithm. Right plots present the relative positions of cluster representatives over time visualized using PCA precomputed on the entire dataset and applied to minority cluster representatives in each block.