

Rcpp FAQ

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This document attempts to answer the most Frequently Asked Questions (FAQ) regarding the Rcpp (Eddelbuettel *et al.*, 2019a; Eddelbuettel and François, 2011; Eddelbuettel, 2013) package.

Rcpp | FAQ | R | C++

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1. Getting started

1.1. How do I get started. If you have Rcpp installed, please execute the following command in R to access the introductory vignette (which is a variant of the Eddelbuettel and François (2011) and Eddelbuettel and Balamuta (2017, 2018) papers) for a detailed introduction, ideally followed by at least the Rcpp Attributes (Allaire *et al.*, 2019) vignette:

```
vignette("Rcpp-jss-2011")
vignette("Rcpp-introduction")
vignette("Rcpp-attributes")
```

If you do not have Rcpp installed, these documents should also be available wherever you found this document, *i.e.*, on every mirror site of CRAN.

1.2. What do I need. Obviously, R must be installed. **Rcpp** provides a C++ API as an extension to the R system. As such, it is bound by the choices made by R and is also influenced by how R is configured.

In general, the standard environment for building a CRAN package from source (particularly when it contains C or C++ code) is required. This means one needs:

- a development environment with a suitable compiler (see below), header files and required libraries;
- R should be built in a way that permits linking and possibly embedding of R; this is typically ensured by the `--enable-shared-lib` option;
- standard development tools such as `make` etc.

Also see the [RStudio documentation](#) on pre-requisites for R package development.

1.3. What compiler can I use. On almost all platforms, the GNU Compiler Collection (or `gcc`, which is also the name of its C language compiler) has to be used along with the corresponding `g++` compiler for the C++ language. A minimal suitable version is a final 4.2.* release; earlier 4.2.* were lacking some C++ features (and even 4.2.1, still used on OS X as the last `gcc` release), has issues).

Generally speaking, the default compilers on all the common platforms are suitable.

Specific per-platform notes:

Windows users need the `Rtools` package from the site maintained by Duncan Murdoch which contains all the required tools in a single package; complete instructions specific to Windows are in the ‘R Administration’ manual ([R Core Team, 2018a](#), Appendix D). As of August 2014, it still installs the `gcc/g++ 4.6.*` compiler which limits the ability to use modern C++ standards so only `s-std c++0x` is supported. R 3.1.0 and above detect this and set appropriate flags.

OS X users, as noted in the ‘R Administration’ manual ([R Core Team, 2018a](#), Appendix C.4), need to install the Apple Developer Tools (e.g., `Xcode` (OS X ≤ 10.8) or `Xcode Command Line Tools` (OS X ≥ 10.9) (as well as `gfortran` if R or Fortran-using packages are to be built); also see [FAQ 2.10](#) and [FAQ 2.16](#) below. Depending on whether on OS X release before or after Mavericks is used, different additional installation may be needed. Consult the `r-sig-mac` list (and its archives) for (current) details.

Linux user need to install the standard development packages. Some distributions provide helper packages which pull in all the required packages; the `r-base-dev` package on Debian and Ubuntu is an example.

The `clang` and `clang++` compilers from the LLVM project can also be used. On Linux, they are inter-operable with `gcc` et al. On OS X, they are unfortunately not ABI compatible. The `clang++` compiler is interesting as it emits much more comprehensible error messages than `g++` (though `g++ 4.8` and `4.9` have caught up).

The Intel `icc` family has also been used successfully as its output files can also be combined with those from `gcc`.

1.4. What other packages are useful. Additional packages that we have found useful are:

inline which is invaluable for direct compilation, linking and loading of short code snippets—but now effectively superseded

by the **Rcpp** Attributes (see [FAQ 2.2.2](#) and [FAQ 2.14](#)) feature provided by **Rcpp**;

RUnit is used for unit testing; the package is recommended and will be needed to re-run some of our tests but it is not strictly required during use of **Rcpp**;

rbenchmark to run simple timing comparisons and benchmarks; it is also recommended but not required.

microbenchmark is an alternative for benchmarking.

devtools can help the process of building, compiling and testing a package but it too is entirely optional.

1.5. What licenses can I choose for my code. The **Rcpp** package is licensed under the terms of the [GNU GPL 2 or later](#), just like R itself. A key goal of the **Rcpp** package is to make extending R more seamless. But by *linking* your code against R (as well as **Rcpp**), the combination is bound by the GPL as well. This is very clearly stated at the [FSF website](#):

Linking a GPL covered work statically or dynamically with other modules is making a combined work based on the GPL covered work. Thus, the terms and conditions of the GNU General Public License cover the whole combination.

So you are free to license your work under whichever terms you find suitable (provided they are GPL-compatible, see the [FSF site for details](#)). However, the combined work will remain under the terms and conditions of the GNU General Public License. This restriction comes from both R which is GPL-licensed as well as from **Rcpp** and whichever other GPL-licensed components you may be linking against.

2. Compiling and Linking

2.1. How do I use Rcpp in my package. **Rcpp** has been specifically designed to be used by other packages. Making a package that uses **Rcpp** depends on the same mechanics that are involved in making any R package that use compiled code — so reading the *Writing R Extensions* manual ([R Core Team, 2018c](#)) is a required first step.

Further steps, specific to **Rcpp**, are described in a separate vignette.

```
vignette("Rcpp-package")
```

2.2. How do I quickly prototype my code. There are two toolchains which can help with this:

- The older one is provided by the **inline** package and described in [Section~2.2.1](#).
- Starting with **Rcpp 0.10.0**, the **Rcpp** Attributes feature (described in [Section~2.2.2](#)) offered an even easier alternative via the function `evalCpp`, `cppFunction` and `sourceCpp`.

The next two subsections show an example each.

2.2.1. Using inline. The **inline** package ([Sklyar et al., 2018](#)) provides the functions `cfun` and `cxxfun`. Below is a simple function that uses `accumulate` from the (C++) Standard Template Library to sum the elements of a numeric vector.

```
fx - cxxfunction signature x "numeric"),
  'NumericVector xx x)
  return wrap
    std::accumulate xx.begin ),
                      xx.end ),
                      0.0)
  ) ',
  plugin "Rcpp")
res - fx seq 1, 10, by 0.5))
res
# [1] 104.5
```

One might want to use code that lives in a C++ file instead of writing the code in a character string in R. This is easily achieved by using `readLines`:

```
fx - cxxfunction signature ),
  paste readLines "myfile.cpp"),
  collapse "\n"),
  plugin "Rcpp")
```

The verbose argument of `cxxfunction` is very useful as it shows how `inline` runs the show.

2.2.2. Using Rcpp Attributes. Rcpp Attributes (Allaire et al., 2019), and also discussed in FAQ 2.14 below, permits an even easier route to integrating R and C++. It provides three key functions. First, `evalCpp` provide a means to evaluate simple C++ expression which is often useful for small tests, or to simply check if the toolchain is set up correctly. Second, `cppFunction` can be used to create C++ functions for R use on the fly. Third, `Rcpp::sourceCpp` can integrate entire files in order to define multiple functions.

The example above can now be rewritten as:

```
cppFunction 'double accu NumericVector x) {
  return
    std::accumulate x.begin ), x.end ), 0.0)
}'
res - accu seq 1, 10, by 0.5))
res
# [1] 104.5
```

The `cppFunction` parses the supplied text, extracts the desired function names, creates the required scaffolding, compiles, links and loads the supplied code and makes it available under the selected identifier.

Similarly, `sourceCpp` can read in a file and compile, link and load the code therein.

2.3. How do I convert my prototyped code to a package. Since release 0.3.5 of `inline`, one can combine FAQ 2.2.1 and FAQ 2.1. See `help "package.skeleton-methods"` once `inline` is loaded and use the skeleton-generating functionality to transform a prototyped function into the minimal structure of a package. After that you can proceed with working on the package in the spirit of FAQ 2.1.

Rcpp Attributes (Allaire et al., 2019) also offers a means to convert functions written using Rcpp Attributes into a function via the `compileAttributes` function; see the vignette for details.

2.4. How do I quickly prototype my code in a package. The simplest way may be to work directly with a package. Changes to both the R and C++ code can be compiled and tested from the command line via:

```
R CMD INSTALL mypkg && \
  Rscript --default-packages mypkg -e \
    'someFunctionToTickle 3.14)'
```

This first installs the packages, and then uses the command-line tool `Rscript` (which ships with R) to load the package, and execute the R expression following the `-e` switch. Such an expression can contain multiple statements separated by semicolons. `Rscript` is available on all three core operating systems.

On Linux, one can also use `r` from the `littler` package by Horner and Eddelbuettel which is an alternative front end to R designed for both `#!` (hashbang) scripting and command-line use. It has slightly faster start-up times than `Rscript`; and both give a guaranteed clean slate as a new session is created.

The example then becomes

```
R CMD INSTALL mypkg && \
  r -l mypkg -e 'someFunctionToTickle 3.14)'
```

The `-l` option calls `'suppressMessages(library(mypkg))'` before executing the R expression. Several packages can be listed, separated by a comma.

More choice are provide by the `devtools` package, and by using RStudio. See the respective documentation for details.

2.5. But I want to compile my code with R CMD SHLIB. The recommended way is to create a package and follow FAQ 2.1. The alternate recommendation is to use `inline` and follow FAQ 2.2.1 because it takes care of all the details.

However, some people have shown that they prefer not to follow recommended guidelines and compile their code using the traditional R CMD SHLIB. To do so, we need to help SHLIB and let it know about the header files that `Rcpp` provides and the C++ library the code must link against.

On the Linux command-line, you can do the following:

```
# if Rcpp older than 0.11.0
export PKG_LIBS `Rscript -e "Rcpp::LdFlags )" `
export PKG_CXXFLAGS \
  `Rscript -e "Rcpp::CxxFlags )" `
R CMD SHLIB myfile.cpp
```

which first defines and exports two relevant environment variables which R CMD SHLIB then relies on. On other operating systems, appropriate settings may have to be used to define the environment variables.

This approach corresponds to the very earliest ways of building programs and can still be found in some deprecated documents (as e.g. some of Dirk's older 'Intro to HPC with R' tutorial slides). It is still not recommended as there are tools and automation mechanisms that can do the work for you.

`Rcpp` versions 0.11.0 or later can do with the definition of `PKG_LIBS` as a user-facing library is no longer needed (and hence no longer shipped with the package). One still needs to set `PKG_CXXFLAGS` to tell R where the `Rcpp` headers files are located.

Once R CMD SHLIB has created the dynamically-loadable file (with extension `.so` on Linux, `.dylib` on OS X or `.dll` on Windows), it can be loaded in an R session via `dyn.load`, and the

function can be executed via `.Call`. Needless to say, we *strongly* recommend using a package, or at least `Rcpp` Attributes as either approach takes care of a lot of these tedious and error-prone manual steps.

2.6. But R CMD SHLIB still does not work. We have had reports in the past where build failures occurred when users had non-standard code in their `~/Rprofile` or `Rprofile.site` (or equivalent) files.

If such code emits text on `stdout`, the frequent and implicit invocation of `Rscript -e "..."` (as in FAQ 2.5 above) to retrieve settings directly from `Rcpp` will fail.

You may need to uncomment such non-standard code, or protect it by wrapping it inside `if (interactive)`, or possibly try to use `Rscript --vanilla` instead of plain `Rscript`.

2.7. What about LinkingTo. R has only limited support for cross-package linkage.

We now employ the `LinkingTo` field of the `DESCRIPTION` file of packages using `Rcpp`. But this only helps in having R compute the location of the header files for us.

The actual library location and argument still needs to be provided by the user. How to do so has been shown above, and we recommend you use either FAQ 2.1 or FAQ 2.2.1 both which use the `Rcpp` function `Rcpp:::LdFlags`.

If and when `LinkingTo` changes and lives up to its name, we will be sure to adapt `Rcpp` as well.

An important change arrived with `Rcpp` release 0.11.0 and concerns the automatic registration of functions; see Section 2.15 below.

2.8. Does Rcpp work on windows. Yes of course. See the Windows binaries provided by CRAN.

2.9. Can I use Rcpp with Visual Studio. Not a chance.

And that is not because we are meanies but because R and Visual Studio simply do not get along. As `Rcpp` is all about extending R with C++ interfaces, we are bound by the available toolchain. And R simply does not compile with Visual Studio. Go complain to its vendor if you are still upset.

2.10. I am having problems building Rcpp on macOS, any help.

There are three known issues regarding `Rcpp` build problems on macOS. If you are building packages with `RcppArmadillo`, there is yet another issue that is addressed separately in FAQ 2.16 below.

2.10.1. Lack of a Compiler. By default, macOS does not ship with an active compiler. Depending on the R version being used, there are different development environment setup procedures. For the current R version, we recommend observing the official procedure used in Section 6.3.2 macOS and Section C.3 macOS of the *R Installation and Administration* manual.

2.10.2. Differing macOS R Versions Leading to Binary Failures. There are currently *three* distinct versions of R for macOS. The first version is a legacy version meant for macOS 10.6 (Snow Leopard) - 10.8 (Mountain Lion). The second version is for more recent system macOS 10.9 (Mavericks) and 10.10 (Yosemite). Finally, the third and most up-to-date version supports macOS 10.11 (El Capitan), 10.12 (Sierra), and 10.13 (High Sierra). The distinction comes as a result of a change in the compilers shipped with the operating system as highlighted previously. As a result, avoid sending **package**

binaries to collaborators if they are working on older operating systems as the R binaries for these versions will not be able to mix. In such cases, it is better to provide collaborators with the **package source** and allow them to build the package locally.

2.10.3. OpenMP Support. By default, the macOS operating environment lacks the ability to parallelize sections of code using the [OpenMP](http://openmp.org/wp/) standard. Within R 3.4.*, the default developer environment was *enabled* to allow for OpenMP to be used on macOS by using a non-default toolchain provided by R Core Team maintainers for macOS. Having said this, it is still important to protect any reference to OpenMP as some users may not yet have the ability to use OpenMP.

To setup the appropriate protection for using OpenMP, the process is two-fold. First, protect the inclusion of headers with:

```
#ifdef _OPENMP
#include omp.h
#endif
```

Second, when parallelizing portions of code use:

```
#ifdef _OPENMP
// multithreaded OpenMP version of code
#else
// single-threaded version of code
#endif
```

Under this approach, the code will be *statically* parallelized when support exists for OpenMP on Windows, macOS, and Linux.

2.10.4. Additional Information and Help. Below are additional resources that provide information regarding compiling `Rcpp` code on macOS.

1. A helpful post was provided by Brian Ripley regarding the use of compiling R code with macOS in April 2014 *on the r-sig-mac list*, which is generally recommended for OS X-specific questions and further consultation.
2. Another helpful write-up for installation / compilation on OS X Mavericks is provided *by the BioConductor project*.
3. Lastly, another resource that exists for installation / compilation help is provided at <http://thecoatlessprofessor.com/programming/r-compiler-tools-for-rcpp-on-os-x/>.

Note: If you are running into trouble compiling code with `RcppArmadillo`, please also see FAQ 2.16 listed below.

2.11. Does Rcpp work on solaris/suncc. Yes, it generally does. But as we do not have access to such systems, some issues persist on the CRAN test systems.

2.12. Does Rcpp work with Revolution R. We have not tested it yet. `Rcpp` might need a few tweaks to work with the compilers used by Revolution R (if those differ from the defaults).

2.13. Is it related to Rho (formerly CXXR). Rho, previously known as CXXR, is an ambitious project that aims to totally refactor the R interpreter in C++. There are a few similarities with `Rcpp` but the projects are unrelated.

Rho / CXXR and `Rcpp` both want R to make more use of C++ but they do it in very different ways.

2.14. How do I quickly prototype my code using Attributes. Rcpp version 0.10.0 and later offer a new feature ‘Rcpp Attributes’ which is described in detail in its own vignette (Allaire *et al.*, 2019). In short, it offers functions `evalCpp`, `cppFunction` and `sourceCpp` which extend the functionality of the `cxxfunction` function.

2.15. What about the new ‘no-linking’ feature. Starting with Rcpp 0.11.0, functionality provided by Rcpp and used by packages built with Rcpp accessed via the registration facility offered by R (and which is used by `lme4` and `Matrix`, as well as by `xts` and `zoo`). This requires no effort from the user / programmer, and even frees us from explicit linking instruction. In most cases, the files `src/Makevars` and `src/Makevars.win` can now be removed. Exceptions are the use of `RcppArmadillo` (which needs an entry `PKG_LIBS` \neq `LAPACK_LIBS`) \neq `BLAS_LIBS`) \neq `FLIBS`)) and packages linking to external libraries they use.

But for most packages using Rcpp, only two things are required:

- an entry in `DESCRIPTION` such as `Imports: Rcpp` (which may be versioned as in `Imports: Rcpp 0.11.0`), and
- an entry in `NAMESPACE` to ensure Rcpp is correctly instantiated, for example `importFrom Rcpp, evalCpp`).

The name of the symbol does not really matter; once one symbol is imported all symbols should be available.

2.16. I am having problems building RcppArmadillo on macOS, any help. Odds are your build failures are due to the absence of `gfortran` and its associated libraries. The errors that you may receive are related to either `-lgfortran` or `-lquadmath`.

To rectify the root of these errors, there are two options available. The first option is to download and use a fixed set of `gfortran` binaries that are used to compile R for macOS (e.g. given by the maintainers of the macOS build). The second option is to either use pre-existing `gfortran` binaries on your machine or download the latest. These options are described in-depth in [Section C.3 macOS of the R Installation and Administration manual](#). Please consult this manual for up-to-date information regarding `gfortran` binaries on macOS. We have also documented *other* common macOS compile issues in [Section FAQ 2.10](#).

3. Examples

The following questions were asked on the `Rcpp-devel` mailing list, which is our preferred place to ask questions as it guarantees exposure to a number of advanced Rcpp users. The [StackOverflow tag for rcpp](#) is an alternative; that site is also easily searchable.

Several dozen fully documented examples are provided at the [Rcpp Gallery](#) – which is also open for new contributions.

3.1. Can I use templates with Rcpp.

I’m curious whether one can provide a class definition inline in an R script and then initialize an instance of the class and call a method on the class, all inline in R.

This question was initially about using templates with `inline`, and we show that (older) answer first. It is also easy with Rcpp Attributes which is what we show below.

3.1.1. Using inline with Templated Code. Most certainly, consider this simple example of a templated class which squares its argument:

```
inc - 'template typename T
      class square :
      public std::unary_function T,T {
      public:
        T operator ( T t) const {
          return t*t
        }
      }
      '

src - '
      double x  Rcpp::as double xs)
      int i  Rcpp::as int is)
      square double sqdbl
      square int sqint
      return Rcpp::DataFrame::create
             (Rcpp::Named "x", sqdbl x)),
             (Rcpp::Named "i", sqint i)))
      ,

fun - cxxfunction signature xs "numeric",
      is "integer"),
      body src, include inc,
      plugin "Rcpp")

fun 2.2, 3L)
#      x i
# 1 4.84 9
```

3.1.2. Using Rcpp Attributes with Templated Code. We can also use ‘Rcpp Attributes’ (Allaire *et al.*, 2019)—as described in [FAQ 2.2.2](#) and [FAQ 2.14](#) above. Simply place the following code into a file and use `sourceCpp` on it. It will even run the R part at the end.

```
#include Rcpp.h

template typename T class square :
  public std::unary_function T,T {
  public:
    T operator ( T t) const {
      return t*t
    }
  }

// [[Rcpp::export]]
Rcpp::DataFrame fun double x, int i) {
  square double sqdbl
  square int sqint
  return Rcpp::DataFrame::create
         (Rcpp::Named "x", sqdbl x)),
         (Rcpp::Named "i", sqint i)))
}

/** R
fun(2.2, 3L)
*/
```

3.2. Can I do matrix algebra with Rcpp.

Rcpp allows element-wise operations on vector and matrices through operator overloading and STL interface, but what if I want to multiply a matrix by a vector, etc
...

Currently, **Rcpp** does not provide binary operators to allow operations involving entire objects. Adding operators to **Rcpp** would be a major project (if done right) involving advanced techniques such as expression templates. We currently do not plan to go in this direction, but we would welcome external help. Please send us a design document.

However, we have developed the **RcppArmadillo** package (Eddelbuettel et al., 2019b; Eddelbuettel and Sanderson, 2014) that provides a bridge between **Rcpp** and **Armadillo** (Sanderson, 2010). **Armadillo** supports binary operators on its types in a way that takes full advantage of expression templates to remove temporaries and allow chaining of operations. That is a mouthful of words meaning that it makes the code go faster by using fiendishly clever ways available via the so-called template meta programming, an advanced C++ technique. Also, the **RcppEigen** package (Bates and Eddelbuettel, 2013) provides an alternative using the **Eigen** template library.

3.2.1. Using inline with RcppArmadillo. The following example is adapted from the examples available at the project page of **Armadillo**. It calculates $X^T Y^{-1} X$

```
lines  '// copy the data to armadillo structures
arma::colvec x  Rcpp::as_arma::colvec  x_)
arma::mat Y  Rcpp::as_arma::mat  Y_)
arma::colvec z  Rcpp::as_arma::colvec  z_)

// calculate the result
double result  arma::as_scalar
              arma::trans x) * arma::inv Y) * z
              )

// return it to R
return Rcpp::wrap  result ) '

writeLines a, file  "myfile.cpp")
```

If stored in a file `myfile.cpp`, we can use it via **inline**:

```
fx - cxxfunction signature x_ "numeric",
                        Y_ "matrix",
                        z_ "numeric" ),
      paste readLines "myfile.cpp"),
      collapse "\n"),
      plugin "RcppArmadillo" )
fx 1:4, diag 4), 1:4)
```

The focus is on the code `arma::trans x) * arma::inv Y) * z`, which performs the same operation as the R code `t(x) %*% solve(Y) %*% z`, although **Armadillo** turns it into only one operation, which makes it quite fast. **Armadillo** benchmarks against other C++ matrix algebra libraries are provided on the **Armadillo website**.

It should be noted that code below depends on the version 0.3.5 of **inline** and the version 0.2.2 of **RcppArmadillo**.

3.2.2. Using Rcpp Attributes with RcppArmadillo. We can also write the same example for use with **Rcpp** Attributes:

```
#include RcppArmadillo.h

// [[Rcpp::depends(RcppArmadillo)]]
```

```
// [[Rcpp::export]]
double fx arma::colvec x, arma::mat Y,
        arma::colvec z) {
  // calculate the result
  double result  arma::as_scalar
              arma::trans x) * arma::inv Y) * z
              )
  return result
}

/** R
fx(1:4, diag(4), 1:4)
*/
```

Here, the additional `Rcpp::depends RcppArmadillo` ensures that code can be compiled against the **RcppArmadillo** header, and that the correct libraries are linked to the function built from the supplied code example.

Note how we do not have to concern ourselves with conversion; R object automatically become (Rcpp)Armadillo objects and we can focus on the single computing a (scalar) result.

3.3. Can I use code from the Rmath header and library with Rcpp.

Can I call functions defined in the **Rmath** header file and the standalone math library for R—as for example the random number generators?

Yes, of course. This math library exports a subset of R, but **Rcpp** has access to much more. Here is another simple example. Note

```
# [1] -10.6125 151.1522 -9.4659 201.8424 -6.2714
```

This illustrates the `Rcpp` Attributes adds the required `RNGScope` object for us. It also shows how setting the seed from R affects draws done via C++ as well as R, and that identical random number draws are obtained.

3.4. Can I use NA and Inf with Rcpp.

R knows about NA and Inf. How do I use them from C++?

Yes, see the following example:

```
src - 'Rcpp::NumericVector v 4)
      v[0] R_NegInf // -Inf
      v[1] NA_REAL  // NA
      v[2] R_PosInf // Inf
      v[3] 42       // c.f. Hitchhiker Guide
      return Rcpp::wrap v) '
fun - cxxfunction signature ), src, plugin "Rcpp")
fun )
# [1] -Inf NA Inf 42
```

Similarly, for `Rcpp` Attributes:

```
#include Rcpp.h

// [[Rcpp::export]]
Rcpp::NumericVector fun void) {
  Rcpp::NumericVector v 4)
  v[0] R_NegInf // -Inf
  v[1] NA_REAL  // NA
  v[2] R_PosInf // Inf
  v[3] 42       // c.f. Hitchhiker Guide
  return v
}
```

3.5. Can I easily multiply matrices.

Can I multiply matrices easily?

Yes, via the `RcppArmadillo` package which builds upon `Rcpp` and the wonderful `Armadillo` library described above in FAQ 3.2:

```
txt - 'arma::mat Am Rcpp::as arma::mat A)
      arma::mat Bm Rcpp::as arma::mat B)
      return Rcpp::wrap Am * Bm ) '
mmult - cxxfunction signature A "numeric",
        B "numeric",
        body txt,
        plugin "RcppArmadillo")
A - matrix 1:9, 3, 3)
B - matrix 9:1, 3, 3)
C - mmult A, B)
C
```

`Armadillo` supports a full range of common linear algebra operations.

The `RcppEigen` package provides an alternative using the `Eigen` template library.

`Rcpp` Attributes, once again, makes this even easier:

```
#include RcppArmadillo.h

// [[Rcpp::depends(RcppArmadillo)]]

// [[Rcpp::export]]
arma::mat mult arma::mat A, arma::mat B) {
  return A*B
}

/** R
A <- matrix(1:9, 3, 3)
B <- matrix(9:1, 3, 3)
mult(A,B)
*/
```

which can be built, and run, from R via a simple `sourceCpp` call—and will also run the small R example at the end.

3.6. How do I write a plugin for inline and/or Rcpp Attributes.

How can I create my own plugin for use by the `inline` package?

Here is an example which shows how to it using `GSL` libraries as an example. This is merely for demonstration, it is also not perfectly general as we do not detect locations first—but it serves as an example:

```
# simple example of seeding RNG and
# drawing one random number
gslrng - '
int seed Rcpp::as int par)
gsl_rng_env_setup )
gsl_rng *r gsl_rng_alloc gsl_rng_default)
gsl_rng_set r, unsigned long) seed)
double v gsl_rng_get r)
gsl_rng_free r)
return Rcpp::wrap v) '

plug - Rcpp::Rcpp.plugin.maker
include.before "#include gsl/gsl_rng.h ",
libs paste
"-L/usr/local/lib/R/site-library/Rcpp/lib -lRcpp",
"-Wl,-rpath,/usr/local/lib/R/site-library/Rcpp/lib",
"-L/usr/lib -lgsl -lgslcblas -lm")
)
registerPlugin "gslDemo", plug )
fun - cxxfunction signature par "numeric",
        gslrng, plugin "gslDemo")
fun 0)
```

Here the `Rcpp` function `Rcpp.plugin.maker` is used to create a plugin ‘plug’ which is then registered, and subsequently used by `inline`.

The same plugins can be used by `Rcpp` Attributes as well.

3.7. How can I pass one additional flag to the compiler.

How can I pass another flag to the `g++` compiler without writing a new plugin?

The quickest way is to modify the return value from an existing plugin. Here we use the default one from `Rcpp` itself in

order to pass the new flag `-std c++0x`. As it does not set the `PKG_CXXFLAGS` variable, we simply assign this. For other plugins, one may need to append to the existing values instead.

```
myplugin - getPlugin "Rcpp")
myplugin$env$PKG_CXXFLAGS - "-std c++11"
f - cxxfunction signature ),
  settings myplugin, body '
  // fails without -std c++0x
  std::vector<double> x { 1.0, 2.0, 3.0 }
  return Rcpp::wrap(x)
' )
f )
```

For Rcpp Attributes, the attributes `Rcpp::plugin` can be used. Currently supported plugins are for C++11 as well as for OpenMP.

3.8. How can I set matrix row and column names.

Ok, I can create a matrix, but how do I set its row and column names?

Pretty much the same way as in R itself: We define a list with two character vectors, one each for row and column names, and assign this to the `dimnames` attribute:

```
src - '
  Rcpp::NumericMatrix x(2,2)
  x.fill(42) // or another value
  Rcpp::List dimnms // list with 2 vecs
  Rcpp::List::create // with static names
    Rcpp::CharacterVector::create("cc", "dd"),
    Rcpp::CharacterVector::create("ee", "ff")
  )
  // and assign it
  x.attr("dimnames") = dimnms
  return x)
'
fun - cxxfunction signature ),
  body src, plugin "Rcpp")
fun )
```

The same logic, but used with Rcpp Attributes:

```
#include Rcpp.h

// [[Rcpp::export]]
Rcpp::List fun(void) {
  Rcpp::NumericMatrix x(2,2)
  x.fill(42) // or another value
  Rcpp::List dimnms // list with 2 vecs
  Rcpp::List::create // with static names
    Rcpp::CharacterVector::create("cc", "dd"),
    Rcpp::CharacterVector::create("ee", "ff")
  // and assign it
  x.attr("dimnames") = dimnms
  return x)
}
```

3.9. Why can long long types not be cast correctly. That is a good and open question. We rely on the basic R types, notably integer and numeric. These can be cast to and from C++ types without

problems. But there are corner cases. The following example, contributed by a user, shows that we cannot reliably cast long types (on a 64-bit machines).

```
BigInts - cxxfunction signature ),
  'std::vector<long> bigint'
```


actually use macros and code generator scripts to explicitly enumerate arguments, and that number has to stop at some limit. We chose 20.

A good discussion is available at [this StackOverflow question](#) concerning data.frame creation with **Rcpp**. One solution offers a custom `ListBuilder` class to circumvent the limit; another suggests to simply nest lists.

3.12. Can I use default function parameters with Rcpp. Yes, you can use default parameters with *so* limitations. The limitations are mainly related to string literals and empty vectors. This is what is currently supported:

- String literals delimited by quotes (e.g. "foo")
- Integer and Decimal numeric values (e.g. 10 or 4.5)

4.3. Where can I ask further questions. The **Rcpp-devel** mailing list hosted at R-forge is by far the best place. You may also want to look at the list archives to see if your question has been asked before.

You can also use **StackOverflow** via its ‘**rcpp**’ tag.

4.4. Where can I read old questions and answers. The normal **Rcpp-devel** mailing list hosting at R-forge contains an archive, which can be searched via **swish**.

Alternatively, one can also use **Mail-Archive on Rcpp-devel** which offers web-based interfaces, including searching.

4.5. I like it. How can I help. We maintain a list of **open issues in the Github repository**. We welcome pull requests and suggest that code submissions come corresponding unit tests and, if applicable, documentation.

If you are willing to donate time and have skills in C++, let us know. If you are willing to donate money to sponsor improvements, let us know too.

You can also spread the word about **Rcpp**. There are many packages on CRAN that use C++, yet are not using **Rcpp**. You could blog about it, or get the word out otherwise.

Last but not least the **Rcpp Gallery** is open for user contributions.

4.6. I don't like it. How can I help. It is very generous of you to still want to help. Perhaps you can tell us what it is that you dislike. We are very open to **constructive** criticism.

4.7. Can I have commercial support for Rcpp. Sure you can. Just send us an email, and we will be happy to discuss the request.

4.8. I want to learn quickly. Do you provide training courses. Yes. Just send us an email.

4.9. Where is the code repository. From late 2008 to late 2013, we used the **Subversion repository at R-Forge** which contained **Rcpp** and a number of related packages. It still has the full history as well as number of support files.

We have since switched to a **Git repository at Github** for **Rcpp** (as well as for **RcppArmadillo** and **RcppEigen**).

5. Known Issues

Contained within this section is a list of known issues regarding **Rcpp**. The issues listed here are either not able to be fixed due to breaking application binary interface (ABI), would impact the ability to reproduce pre-existing results, or require significant work. Generally speaking, these issues come to light only when pushing the edge capabilities of **Rcpp**.

5.1. Rcpp changed the (const) object I passed by value. **Rcpp** objects are wrappers around the underlying R objects’ SEXP, or S-expression. The SEXP is a pointer variable that holds the location of where the R object data has been stored (**R Core Team, 2018b**, Section 1.1). That is to say, the SEXP does *not* hold the actual data of the R object but merely a reference to where the data resides. When creating a new **Rcpp** object for an R object to enter C++, this object will use the same SEXP that powers the original R object if the types match otherwise a new SEXP must be created to be type safe. In essence, the underlying SEXP objects are passed by reference without explicit copies being made into C++. We refer to this arrangement as a *proxy*.

As for the actual implementation, there are a few consequences of the proxy model. The foremost consequence within this paradigm is that pass by value is really a pass by reference. In essence, the distinction between the following two functions is only visual sugar:

```
void implicit_ref NumericVector X)
void explicit_ref NumericVector X)
```

In particular, when one is passing by value what occurs is the instantiation of the new **Rcpp** object that uses the same SEXP for the R object. As a result, the **Rcpp** object is “linked” to the original R object. Thus, if an operation is performed on the **Rcpp** object, such as adding 1 to each element, the operation also updates the R object causing the change to be propagated to R’s interactive environment.

```
#include Rcpp.h

// [[Rcpp::export]]
void implicit_ref Rcpp::NumericVector X) {
    X    X + 1.0
}

// [[Rcpp::export]]
void explicit_ref Rcpp::NumericVector X) {
    X    X + 1.0
}
```

R use

```
a - 1.5:4.5
b - 1.5:4.5
implicit_ref a)
a
# [1] 2.5 3.5 4.5 5.5
explicit_ref b)
b
# [1] 2.5 3.5 4.5 5.5
```

There are two exceptions to this rule. The first exception is that a deep copy of the object can be made by explicit use of **Rcpp::clone**). In this case, the cloned object has no link to the original R object. However, there is a time cost associated with this procedure as new memory must be allocated and the previous values must be copied over. The second exception, which was previously foreshadowed, is encountered when **Rcpp** and R object types do not match. One frequent example of this case is when the R object generated from **seq**) or **a:b** reports a class of “integer” while the **Rcpp** object is setup to receive the class of “numeric” as its object is set to **NumericVector** or **NumericMatrix**. In such cases, this would lead to a new SEXP object being created behind the scenes and, thus, there would *not* be a link between the **Rcpp** object and R object. So, any changes in C++ would not be propagated to R unless otherwise specified.

```
#include Rcpp.h

// [[Rcpp::export]]
void int_vec_type Rcpp::IntegerVector X) {
    X    X + 1.0
}
```

```
// [[Rcpp::export]]
void num_vec_type Rcpp::NumericVector X) {
  X  X + 1.0
}
```

R use:

```
a - 1:5
b - 1:5
class a)
# [1] "integer"
int_vec_type a)
a # variable a changed as a side effect
# [1] 2 3 4 5 6
num_vec_type b)
b # b unchanged as copy was made for numeric
# [1] 1 2 3 4 5
```

With this being said, there is one last area of contention with the proxy model: the keyword `const`. The `const` declaration indicates that an object is not allowed to be modified by any action. Due to the way the proxy model paradigm works, there is a way to “override” the `const` designation. Simply put, one can create a new **Rcpp** object without the `const` declaration from a pre-existing one. As a result, the new **Rcpp** object would be allowed to be modified by the compiler and, thus, modifying the initial SEXP object. Therefore, the initially secure R object would be altered. To illustrate this phenomenon, consider the following scenario:

```
#include Rcpp.h

// [[Rcpp::export]]
Rcpp::IntegerVector const_override_ex
  const Rcpp::IntegerVector X) {

  Rcpp::IntegerVector Y X) // Create object
                           // from SEXP

  Y  Y * 2                 // Modify new object

  return Y                 // Return new object
}
```

R use:

```
x - 1:10 # an integer sequence
# returning an altered value
const_override_ex x)
# [1] 2 4 6 8 10 12 14 16 18 20
# but the original value is altered too!
x
# [1] 2 4 6 8 10 12 14 16 18 20
```

So we see that with SEXP objects, the `const` declaration can be circumvented as it is really a pointer to the underlying R object.

5.2. Issues with implicit conversion from an Rcpp object to a scalar or other Rcpp object. Not all **Rcpp** expressions are directly compatible with `operator`. Compatibility issues stem from many **Rcpp** objects and functions returning an intermediary result which requires an explicit conversion. In such cases, the user may need to assist the compiler with the conversion.

There are two ways to assist with the conversion. The first is to construct storage variable for a result, calculate the result,

and then store a value into it. This is typically what is needed when working with `Character Type` and `String` in **Rcpp** due to the `Rcpp::internal::string_proxy` class. Within the following code snippet, the aforementioned approach is emphasized:

```
#include Rcpp.h

// [[Rcpp::export]]
std::string explicit_string_conv
  Rcpp::CharacterVector X) {

  std::string s // define storage
  s  X[0]       // assign from CharacterVector

  return s
}
```

If one were to use a direct allocation and assignment strategy, e.g. `std::string s X[0]`, this would result in the compiler triggering a conversion error on so < platforms. The error would be similar to:

```
error: no viable conversion from 'Proxy'
(aka 'string_proxy 16 ') to 'std::string'
(aka 'basic_string char, char_traits char ,
allocator char ')
```

The second way to help the compiler is to use an explicit **Rcpp** type conversion function, if one were to exist. Examples of **Rcpp** type conversion functions include `as T`), `.get`) for `cumsum`), `is_true`) and `is_false`) for `any`) or `all`).

5.3. Using `operator=` with a scalar replaced the object instead of filling element-wise. Assignment using the `operator` with either `Vector` and `Matrix` classes will not elicit an element-wise fill. If you seek an element-wise fill, then use the `.fill`) member method to propagate a single value throughout the object. With this being said, the behavior of `operator` differs for the `Vector` and `Matrix` classes.

The implementation of the `operator` for the `Vector` class will replace the existing vector with the assigned value. This behavior is valid even if the assigned value is a scalar value such as 3.14 or 25 as the object is cast into the appropriate **Rcpp** object type. Therefore, if a `Vector` is initialized to have a length of 10 and a scalar is assigned via `operator` , then the resulting `Vector` would have a length of 1. See the following code snippet for the aforementioned behavior.

```
#include Rcpp.h

// [[Rcpp::export]]
void vec_scalar_assign(int n, double fill_val) {
  Rcpp::NumericVector X n)
  Rcpp::Rcout "Value of Vector "
    "on Creation: "
    std::endl  X  std::endl

  X  fill_val

  Rcpp::Rcout "Value of Vector "
    "after Assignment: "
```

```
std::endl X std::endl
}
```

R use:

```
vec_scalar_assign 5L, 3.14)
# Value of Vector on Creation:
# 0 0 0 0 0
# Value of Vector after Assignment:
# 3.14
```

Now, the `Matrix` class does not define its own `operator` but instead uses the `Vector` class implementation. This leads to unexpected results while attempting to use the assignment operator with a scalar. In particular, the scalar will be coerced into a square `Matrix` and then assigned. For an example of this behavior, consider the following code:

```
#include Rcpp.h

// [[Rcpp::export]]
void mat_scalar_assign(int n, double fill_val) {
  Rcpp::NumericMatrix X(n, n)
  Rcpp::Rcout "Value of Matrix "
    "on Creation: "
    std::endl X std::endl

  X fill_val

  Rcpp::Rcout "Value of Matrix "
    "after Assignment: "
    std::endl X std::endl
}
```

R use:

```
mat_scalar_assign 2L, 3.0)
# Value of Matrix on Creation:
# 0.00000 0.00000
# 0.00000 0.00000
#
# Value of Matrix after Assignment:
# 0.00000 0.00000 0.00000
# 0.00000 0.00000 0.00000
# 0.00000 0.00000 0.00000
```

5.4. Long Vector support on Windows. Prior to R's 3.0.0, the largest vector one could obtain was at most $2^{31} - 1$ elements. With the release of R's 3.0.0, long vector support was added to allow for largest vector possible to increase up to 2^{52} elements on x64 bit operating systems (c.f. [Long Vectors help entry](#)). Once this was established, support for long vectors within the `Rcpp` paradigm was introduced with `Rcpp` version 0.12.0 (c.f. [Rcpp 0.12.0 announcement](#)).

However, the requirement for using long vectors in `Rcpp` necessitates the presence of compiler support for the `R_xlen_t`, which is platform dependent on how `ptrdiff_t` is implemented. Unfortunately, this means that on the Windows platform the definition of `R_xlen_t` is of type `long` instead of `long long` when compiling under the C++98 specification. Therefore, to solve this issue one must compile under the specification for C++11 or later version.

There are three options to trigger compilation with C++11. The first – and most likely option to use – will be the plugin support offered by `Rcpp` attributes. This is engaged by adding `//`

`[[Rcpp::plugins(cpp11)]]` to the top of the C++ script. For diagnostic and illustrative purposes, consider the following code which checks to see if `R_xlen_t` is available on your platform:

```
#include Rcpp.h
// Force compilation mode to C++11
// [[Rcpp::plugins(cpp11)]]

// [[Rcpp::export]]
bool test_long_vector_support() {
  #ifdef RCPP_HAS_LONG_LONG_TYPES
    return true
  #else
    return false
  #endif
}
```

R use:

```
test_long_vector_support()
# [1] TRUE
```

The remaining two options are for users who have opted to embed `Rcpp` code within an R package. In particular, the second option requires adding `CXX_STD CXX11` to a `Makevars` file found in the `/src` directory. Finally, the third option is to add `SystemRequirements:C++11` in the package's `DESCRIPTION` file.

Please note that the support for C++11 prior to R v3.3.0 on Windows is limited. Therefore, plan accordingly if the goal is to support older versions of R.

5.5. Sorting with STL on a `CharacterVector` produces problematic results.

The Standard Template Library's (STL) `std::sort` algorithm performs adequately for the majority of `Rcpp` data types. The notable exception that makes what would otherwise be a universal quantifier into an existential quantifier is the `CharacterVector` data type. Chiefly, the issue with sorting strings is related to how the `CharacterVector` relies upon the use of `Rcpp::internal::string_proxy`. In particular, `Rcpp::internal::string_proxy` is *not* `MoveAssignable` since the left hand side of `operator const string_proxy & rhs)` is *not* viewed as equivalent to the right hand side before the operation (ISO/IEC, 2011, p. 466, Table 22). This further complicates matters when using `CharacterVector` with `std::swap`, `std::move`, `std::copy` and their variants.

To avoid unwarranted pain with sorting, the preferred approach is to use the `.sort()` member function of `Rcpp` objects. The member function correctly applies the sorting procedure to `Rcpp` objects regardless of type. Though, sorting is slightly problematic due to locale as explained in the next entry. In the interim, the following code example illustrates the preferred approach alongside the problematic STL approach:

```
#include Rcpp.h

// [[Rcpp::export]]
Rcpp::CharacterVector preferred_sort(
  Rcpp::CharacterVector x) {

  Rcpp::CharacterVector y(Rcpp::clone(x))
  y.sort()

  return y
}
```

```

}

// [[Rcpp::export]]
Rcpp::CharacterVector stl_sort
  (Rcpp::CharacterVector x) {

  Rcpp::CharacterVector y  Rcpp::clone x)
  std::sort y.begin (), y.end ())

  return y
}

```

R use:

```

set.seed 123)
X - sample c LETTERS[1:5], letters[1:6]), 11))
# [1] "C" "f" "B" "a" "e" "E" "D" "d" "c" "A" "b"
preferred_sort X)
# [1] "A" "B" "C" "D" "E" "a" "b" "c" "d" "e" "f"
stl_sort X)
# [1] "f" "f" "f" "f" "f" "f" "f" "f" "f" "C" "f"

```

In closing, the results of using the STL approach do change depending on whether `libc++` or `libstdc++` standard library is used to compile the code. When debugging, this does make the issue particularly complex to sort out. Principally, compilation with `libc++` and STL has been shown to yield the correct results. However, it is not wise to rely upon this library as a majority of code is compiled against `libstdc++` as it more complete.

5.6. Lexicographic order of string sorting differs due to capitalization. Comparing strings within R hinges on the ability to process the locale or native-language environment of the string. In R, there is a function called `Scollate` that performs the comparison on locale. Unfortunately, this function has not been made publicly available and, thus, **Rcpp** does *not* have access to it within its implementation of `StrCmp`. As a result, strings that are sorted under the `.sort` member function are ordered improperly. Specifically, if capitalization is present, then capitalized words are sorted together followed by the sorting of lowercase words instead of a mixture of capitalized and lowercase words. The issue is illustrated by the following code example:

```

#include Rcpp.h

// [[Rcpp::export]]
Rcpp::CharacterVector rcpp_sort
  (Rcpp::CharacterVector X) {
  X.sort ()
  return X
}

```

R use:

```

x - c "B", "b", "c", "A", "a")
sort x)
# [1] "a" "A" "b" "B" "c"
rcpp_sort x)
# [1] "A" "B" "a" "b" "c"

```

5.7. Package building fails with ‘symbols not found’. R 3.4.0 and later strongly encourage registering dynamically loadable symbols. In the stronger form (where `.registration TRUE` is added to the

`useDynLib` statement in `NAMESPACE`), only registered symbols can be loaded. This is fully supported by Rcpp 0.12.12 and later, and the required code is added to `src/RcppExports.cpp`.

However, the transition from the previously generated file `src/RcppExports.cpp` to the new one may require running `compileAttributes` twice (which does not happen when, e.g., `devtools` is used). When `Rcpp::compileAttributes` is called, it also calls `tools::package_native_routine_registration_skeleton`, which crawls through usages of `.Call` in the R/ source files of the package to figure out what routines need to be registered. If an older `RcppExports.R` file is discovered, its out-of-date symbol names get picked up, and registration rules for those symbols get written as well. This will register more symbols for the package than are actually defined, leading to an error. This point has been discussed at some length both in the GitHub issue tickets, on StackOverflow and elsewhere.

So if your autogenerated file fails, and a symbols not found error is reported by the linker, consider running `compileAttributes` twice. Deleting `R/RcppExports.R` and `src/RcppExports.cpp` may also work.

5.8. Can we use exceptions and `stop()` across shared libraries?

Within limits, yes. Code that is generated via Rcpp Attributes (see [Allaire et al. \(2019\)](#) and Section 2.2.2) generally handles this correctly and gracefully via the try-catch layer it adds shielding the exception from propagating to another, separate dynamic library.

However, this mechanism relies on dynamic linking with the (system library) `libgcc` providing the C++ standard library (as well as on using the same C++ standard library across all compiled components). But this library is linked statically on Windows putting a limitation on the use of `stop` from within Rcpp Modules ([Eddelbuettel and François, 2019](#)). Some more background on the linking requirement is in [this SO question](#).

References

- Allaire JJ, Eddelbuettel D, François R (2019). *Rcpp Attributes*. Vignette included in R package Rcpp, URL <http://CRAN.R-Project.org/package=Rcpp>.
- Bates D, Eddelbuettel D (2013). “Fast and Elegant Numerical Linear Algebra Using the RcppEigen Package.” *Journal of Statistical Software*, **52**(5), 1–24. URL <http://www.jstatsoft.org/v52/i05/>.
- Eddelbuettel D (2013). *Seamless R and C++ Integration with Rcpp*. Use R! Springer, New York. ISBN 978-1-4614-6867-7.
- Eddelbuettel D, Balamuta JJ (2017). “Extending R with C++: A Brief Introduction to Rcpp.” *PeerJ Preprints*, **5**. doi: [10.7287/peerj.preprints.3188v1/](https://doi.org/10.7287/peerj.preprints.3188v1/).
- Eddelbuettel D, Balamuta JJ (2018). “Extending R with C++: A Brief Introduction to Rcpp.” *The American Statistician*, **72**(1). doi: [10.1080/00031305.2017.1375990](https://doi.org/10.1080/00031305.2017.1375990).
- Eddelbuettel D, François R (2011). “Rcpp: Seamless R and C++ Integration.” *Journal of Statistical Software*, **40**(8), 1–18. URL <http://www.jstatsoft.org/v40/i08/>.
- Eddelbuettel D, François R (2019). *Exposing C++ functions and classes with Rcpp modules*. Vignette included in R package Rcpp, URL <http://CRAN.R-Project.org/package=Rcpp>.
- Eddelbuettel D, François R, Allaire J, Ushey K, Kou Q, Russel N, Chambers J, Bates D (2019a). *Rcpp: Seamless R and C++ Integration*. R package version 1.0.3, URL <http://CRAN.R-Project.org/package=Rcpp>.
- Eddelbuettel D, François R, Bates D, Ni B (2019b). *RcppArmadillo: Rcpp integration for Armadillo templated linear algebra library*. R package version 0.9.800.1.0, URL <http://CRAN.R-Project.org/package=RcppArmadillo>.
- Eddelbuettel D, Sanderson C (2014). “RcppArmadillo: Accelerating R with High-Performance C++ Linear Algebra.” *Computational Statistics and Data*

- Analysis*, **71**, 1054–1063. doi:10.1016/j.csda.2013.02.005. URL <http://dx.doi.org/10.1016/j.csda.2013.02.005>.
- ISO/IEC (2011). “C++ 2011 Standard Document 14882:2011.” ISO/IEC Standard Group for Information Technology / Programming Languages / C++. URL http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=50372.
- R Core Team (2018a). *R Installation and Administration*. R Foundation for Statistical Computing, Vienna, Austria. URL <http://CRAN.R-Project.org/doc/manuals/R-admin.html>.
- R Core Team (2018b). *R internals*. R Foundation for Statistical Computing, Vienna, Austria. URL <http://CRAN.R-Project.org/doc/manuals/R-ints.html>.
- R Core Team (2018c). *Writing R extensions*. R Foundation for Statistical Computing, Vienna, Austria. URL <http://CRAN.R-Project.org/doc/manuals/R-exts.html>.
- Sanderson C (2010). “Armadillo: An open source C++ Algebra Library for Fast Prototyping and Computationally Intensive Experiments.” *Technical report*, NICTA. URL <http://arma.sf.net>.
- Sklyar O, Murdoch D, Smith M, Eddelbuettel D, François R (2018). *inline: Inline C, C++, Fortran function calls from R*. R package version 0.3.15, URL <http://CRAN.R-Project.org/package=inline>.