Transfer of research results into information services and practices: challenges and approaches to software-based library innovation

Abstract

Academic and research libraries are constantly striving to innovate their services based on research and development, for example by collaborating with researchers in funded projects. In particular, results from applied information science and computer science can be used for software-based innovation. This paper presents a general model for transferring these results into information services and practices. There are two ways to put the model into practice: either by exposing research results as beta developments in a laboratory environment, or by carrying out a transfer project to make the innovations integrated, effective and sustainable. Our approach identifies three levels of integration of research results in the form of software artefacts (data, service, application), each of which requires commitment and contributions not only from researchers but also from a library's management and operational staff. Finally, we use a real-world example to illustrate the basic process of transferring a research result, as well as some of the idiosyncrasies and indeterminacy that are inherent in any transfer project.

Keywords: technology transfer, library innovation, laboratory

1. Introduction

In a statement from their recent 'WEITER WISSEN' campaign, some of Germany's largest academic libraries listed 'research and development' as one of their main activities: ‘As academic libraries, we not only provide researchers with curated specialist information and research data, but also develop our own application-oriented infrastructures to make data of all kinds digitally available. We do this by developing software and code, programming algorithms and using Artificial Intelligence (AI) tools to sort, filter and find data in a user-friendly way. At the same time, our applied research addresses fundamental questions about user habits and research routines, thus providing essential insights for designing services that are designed for the next generation of researchers.’ (WEITER WISSEN, 2024)

In addition to their traditional mission of providing information for scholarship, including research and teaching, academic libraries are constantly striving to innovate their services according to some of the latest research findings - if not on their own, then in partnership with researchers, for example in applied computing or information science. To illustrate this, consider the following scenario: a library may be aware of the current impact of conversational artificial intelligence (AI) applications such as ChatGPT, with which its users are quickly becoming familiar. The institution may have doubts about whether its search portal is still up to date, so it is interested in both a study and a prototype of extending the 'classic' list of search results with more conversational options (Fitch, 2023). After evaluating the prototype delivered by a 'task force' team from the library, the latter decides to postpone the idea, mainly due to concerns from legal advisors regarding the regular training of the AI application with copyrighted and negotiated content from publishers.

To demonstrate and expose the 'essential insights' that the campaign addresses, some libraries operate laboratories or simply 'labs' (Chambers, 2019) that serve as a playground for collaboration with external researchers and stakeholders. However, 'science for service' becomes particularly appealing when we consider scenarios of intra-organisational technology transfer. Without the immediate pressure of commercialisation through patents, incubators or start-ups, but under the condition of a considerable degree of proximity and relationship between stakeholders such as researchers, librarians and product managers, we can imagine the integration of research results into a library's services, workflows and information practices as a feasible and appealing go to cooperation. In terms of our introductory scenario, this could mean re-engineering a library's search portal by re-ranking search results and adding options for more conversational information retrieval (IR).

However, a closer look at these promising options may prove challenging. Firstly, there is no certainty that research results will be used as originally intended; research may simply fail because of its uncertainty and potential ineffectiveness, but also as a prerequisite for later success (Backus, 1984). For example, the re-ranking introduced may turn out to be less relevant to users when it comes to more thorough A/B testing. Even if research findings are proven and valuable, they may not be sufficiently interoperable to be immediately integrated into service design or implementation, as is the case with empirical studies or data analysis. Furthermore, even if transferable in a technical or operational sense, the process of gatekeeping by 'practitioners' such as product owners, service managers or, as in our example, licence managers, may prevent research findings from being integrated into a service portfolio. Finally, even when introduced as a product or process innovation, transferred results may fail to gain traction for a variety of reasons: users simply do not perceive or interact with them as intended, they are lost in the update or redesign of the original service environment or workflows, or other properties or features of that service environment outperform them. For example, a library offering an enhanced search interface may find that its users prefer conversational IR in a different environment, whereas they expect to retrieve and access documents as primary sources from a library information system.

What do we mean by research and, in particular, technology transfer? Among the various definitions and characterizations, Roessner (2000) defined technology transfer generally as ‘the movement of know-how, technical knowledge, or technology from one organizational setting to another’. The author continues: ‘Within single organizations such as large, research-intensive private firms, technology transfer has been used to describe the processes by which ideas, proofs-of-concept, and prototypes move from research-related to production-related phases of product development.’ In the context of software-driven digital information or library services, and in line with the cited library campaign 'MORE WISSEN', we interpret these research results more technically as software-driven datasets, algorithms, software components or prototypical applications. Applied to our scenario, we might consider the embedding of documents and user queries and the training of a Large Language Model (LLM) as an experimental result. However, we could also consider results or findings from analytical or empirical investigations, insofar as they have potential implications for the design or implementation of library services. For example, we might interpret the observed reformulation of queries within a user session as an indicator of poor ranking. However, by emphasising software-driven outcomes, we assume that a successful transfer will enhance or improve the targeted service landscape, in particular by introducing new techniques on

the recipient side, be it some library staff or end users. This can have different consequences or effects, one of the most important of which is that 'not only a particular technology, a patent or a physical artefact, but also the knowledge gained by the individual or by the company itself on the characteristics and use of these technologies, which are commonly spread at various levels in the corporate structures: it is clear that if an organization wants to acquire a certain technology, it must integrate internally not only its physical components but also the knowledge and skills needed to use them.' (Battistella et al., 2015) In our case of software-based library services, these additional knowledge and skills affect the library staff responsible for integrating and operating a piece of innovative development, while the end users of a library mainly benefit from the associated functions, datasets or applications. Other meanings of technology transfer we do not address in this paper, in particular the aspect of converting intellectual property rights into commercial value through patents, spin-offs or related business activities.

This is the structure of the rest of the paper: In the following section, we present a basic model for analysing technology transfer as a role-based process. We then explain two operational modes for transfer: either as a straightforward software development and build project, or as a more comprehensive transfer project affecting an organisation's system and service environment. In the following section, we present a real-world scenario to illustrate the idiosyncrasies of a transfer project, while still fitting into the overall transfer model. Finally, we consider some future issues.

2. A basic model for technology transfer

From the extensive literature on inter- and intra-organisational technology transfer, which is not specifically related to libraries, Battistella et al. (2015) extracted a basic model, which we can also adapt for our purpose, to structure the transfer process within a library. This communication-oriented model identifies three actors or roles that are typically involved in a transfer process: the *source*, *sender*, *supplier* or *owner* of a technological innovation; the *recipient*, *receiver*, *target* or *operator* of this innovation; and an *intermediary*, *transmitter*, *broker*, *agent* or *gatekeeper* who facilitates or mediates technology transfer. We explain these roles in more detail by projecting them onto typical actors within the institutional setting of a library.

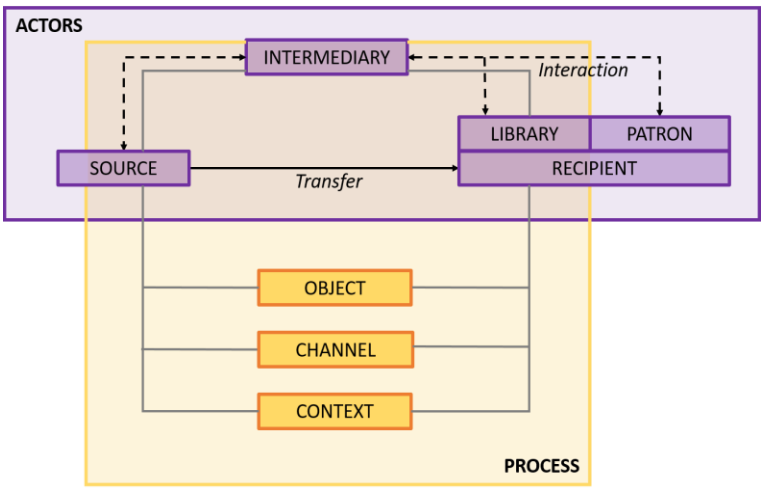

Figure 1. Model for technology transfer (based on Battistella et al. (2015))

2.1. Source

These are researchers or research units within a library that deliver their results as software-based outputs, e.g. trained models, algorithms, APIs, programs, databases or prototypes. As a source, they may interact with service staff or even have strategic or operational responsibility for library services, but sometimes they are more closely associated with a university department or research institute. They may also be external partners to a library, working on a funded project. From the point of view of technology readiness (Armstrong, 2010) and service operations, they tend to deliver immature results and do not have a particular focus on operations; in the early stages of incubation, this may even prevent them from being innovative.

2.2. Recipient

In our setting, this actor is divided into different user groups. We might first think of a library's users or patrons as recipients. Especially when technology transfer is explicitly aimed at innovating a library's products or services, the end users count as the ultimate recipients - if they fail or refuse to interact with the new technology, then the whole transfer is threatened. A second important group of recipients can be identified as the library staff or colleagues responsible for implementing a technological innovation. This group can be further subdivided into those responsible for integrating, maintaining and operating the original research resource, and those who primarily interact with the technology to deliver a library's services. In our example scenario, this would mean that resources would be required for regular training and fine-tuning of the AI application on the one hand, and for delivering the documents ordered as a result of the recommendations on the other.

2.3. Intermediary

As intermediaries, we can identify an individual or organisational unit that mediates between the source of a technological innovation and its recipient. For example, product owners or service managers have the role of identifying innovations and introducing them to their users or customers. In terms of our introductory scenario, this could mean first raising awareness of new options for IR, then initiating or supporting research on them, before promoting the integrated results through workshops or information literacy training. In their role as transmitters, intermediaries are as crucial as any other actor in the transfer process, even if they are not involved in the development or operation of the technology: ‘Intermediaries are agents of the innovation system that facilitate the process of technology/knowledge transfer among people and organizations addressing factors enabling or constraining.’ (Battistella et al., 2015) In their role as gatekeepers, intermediaries are primarily responsible for a library's services and patrons, but at the same time for monitoring and managing technological improvements and innovations from an end-user perspective (Buxton & Malcolm, 1991). To reinforce the latter aspect, in some academic libraries intermediaries are even staffed by researchers, a setting which can be conflicting: researchers acting as transmitters may have a stronger tendency to mediate their own results, whereas non-researchers may be more inclined to make these results available to the user community they represent as 'practitioners'.

In their original model, Battistella et al. (2015) identified three additional entities: the object of the transfer, its channels or mechanisms, and its context. In our context of software-oriented technology transfer, the object is regularly an artefact of software as a material result of the research process. This object is complemented by immaterial, sometimes undocumented or tacit knowledge about how to deal with it (Howells, 1996), and it needs some attention to express (e.g. by defining the functional requirements) and transfer this knowledge for the continuation of the technical innovation. According to our different groups of recipients, we distinguish between the knowledge to interact with the object at the application level and the knowledge to operate and maintain it at the programming and operational level. Although the software industry has invented useful environments and tools for managing the latter (e.g. container technologies for publishing and distributing operational code, code versioning and management, build pipelines for deploying and integrating the software), this does not save us from the challenges of transferring the object into an existing service environment. According to Battistella et al. (2015), 'the transfer of knowledge involves a complex variety of factors, prerequisites and problems of context that influence the process, which can enable or inhibit it'. In this sense, Cumming et al. (2003) had already identified four contextual categories as success factors for knowledge transfer, which we can adapt for our purpose of modelling technology transfer within a library as an organisation:

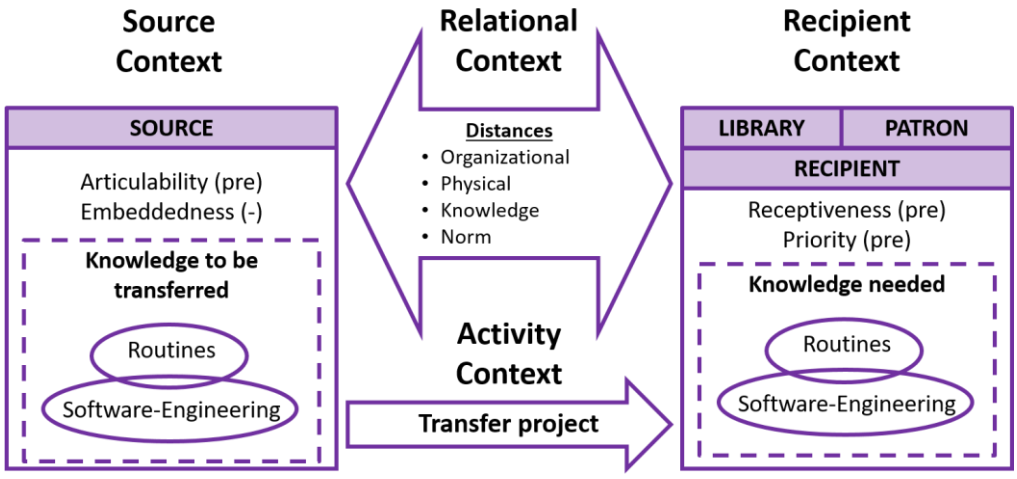

Figure 2. Contexts of knowledge transfer (based on Cumming et al. (2003))

Since a source's knowledge context implies an advance in (technical) knowledge or skills as a natural effect of a researcher's initial developments - sometimes even through the introduction of new software frameworks with which the organisation is not yet familiar - it requires the mediation of this knowledge to a recipient in its dual sense as a library staff member or a patron. Successful mediation depends on two conditions: the receptiveness of the recipient to learn or adopt new technologies, and the willingness to give this adoption a certain priority. The source and the recipient of a technology transfer implicitly share a relational context determined by four basic dimensions of distance: an organisational distance, a physical distance, a knowledge distance and a normative distance. Since we are dealing with the basic scenario of intra-organisational technology transfer in this paper, we can consider the organisational distance to be much shorter than, for example, between a government organisation and a company. However, even within an institution the distance can still be considerable, depending on the organisational structure, culture and governance.

In terms of physical distance, we can think of things like shared offices or diverse teams, which can facilitate collaboration on transfer activities. On the other hand, with regard to home office and remote working as a de facto model for software-related positions, Yang et al. (2022) identified increasing geographical distance and asynchronous communication as one of the main barriers to information exchange, which may also have an impact on successful technology and knowledge transfer.

We have already touched on the issue of knowledge distance: the more the source and receiver overlap in their knowledge of particular library services or data, the more likely and realistic a transfer situation becomes. For example, the more the researcher and the product owner share their views on LLMs and query embedding to support natural language-based IR, the more likely it is that a service innovation in this area will occur. Finally, a minimised normative distance implies that actors within a transfer scenario can harmonise their activities by referring to the same organisational culture and value system. In our setting, this could simply mean that researchers and operational staff share a common technical environment, paradigm, practice or workflow that they regard as constitutive for their work, which may also help to agree on at least technical or formal transfer goals (e.g. open source, Docker for deploying and distributing software results, microservice architecture, hosting of LLM).

3. Two approaches to technology transfer within an institution

It is a common theme in the literature that technology transfer regularly fails, especially when combined with business models and strategies for the commercial exploitation of new technologies (Parker & Mainelli, 2001). Before reflecting too much on the symptoms and causes of such failures, we would like to present two approaches to the transfer of a research result that may also help to prevent 'failure' or at least mitigate the risks of failure at the operational level. The first approach consists of a short-term and limited activity, which is to deploy and present a research result as a dedicated beta application or in a virtual laboratory, as some large academic libraries have set up to publish their latest research results and experiments (Chambers, 2019). The second approach implies a longer-term, more sustainable activity by transferring a research output into a full service in a library's portfolio.

3.1. The beta or laboratory approach

With Phetteplace et al. (2013), we define a library lab ‘as any library program, physical or digital (or a hybrid) in which innovative approaches to library services, tools, or materials are tested in some structured way before being made part of regular workflows, programs, or mission.’ Beyond the crucial aspect of testing or staging innovations, we see library labs as a conceptual, technical, social and organisational framework primarily for developing, running and testing beta applications that relate to a library's existing data, services or workflows. They serve as a staging environment for experimenting with a new technology, but without the productive, operational or legal commitment that would be essential for a regular library service. In terms of our scenario, this could mean simply publishing a prototype of conversational IR trained on a limited set of open access documents, with no options for retrieving or accessing other licensed works.

3.1.1. Conceptual mindset

As the concept of a library lab has emerged in recent years, we can find several examples of it in practice. While Phetteplace et al. (2013) identify a "vast majority of (university) library labs", some of them implemented as makerspaces (Fletcher, 2021), other GLAM institutions run their labs in pursuit of their mission: either the lab supports their organisational transformation by experimenting and testing new practices, workflows and community engagements based on their publicly released collections and data. This mission is quite radical and involves some organisational change management as it affects the basic boundaries, workflows and service portfolio of an organisation. Alternatively, the lab serves as an organisational framework for the evaluation of a library's services in the form of beta applications or prototypes, where some institutional staff, e.g. the responsible service management, guide user involvement and feedback from the community. We would like to focus here on the latter aspect of 'lab validation' (Gorschek et al., 2006) by listing some other key features of this approach:

- Service innovation using *rapid prototyping and related agile programming techniques* such as minimum viable product (MVP), a perpetual beta mindset, and nimble, interdisciplinary and self-contained teams without the need for additional library resources.
- On the other hand, autonomous research and development staff - 'skunkworkers' (Nowviskie, 2013) - who are not overburdened by day-to-day operational tasks and are not hindered by 'bureaucratic' library standards and workflows, but are still aware of them. Their innovations tend to relate to specific aspects of a library's data, workflows, systems, user groups and quality standards.
- *Community involvement and guided feedback* from internal or external users. Regardless of the nature of the innovation (product, service or internal process), explicit feedback from users or beta testers is crucial to the evaluation of the innovation. We can distinguish between feedback from internal 'friendly' users (e.g. library staff interacting with a new technology as part of a backend system), external end users of a service, and external peer groups forming communities (Mahey et al., 2019). In particular, these communities might include a research community and an open source software community, both of which are more engaged with the use of a laboratory's collections, datasets and programming interfaces.
- *Timely documentation and presentation.* In contrast to traditional research publishing workflows, the presentation of innovations by a laboratory encourages timely reporting in the form of blog posts, for example, rather than full scientific papers, which are often subject to lengthy peer review and cumbersome editing processes. In addition, the presentation of an innovation could include not only its scientific origin and outcome, but also references to its laboratory context. For example, we might describe innovations or experiments in terms of a project protocol, which is an ontology or vocabulary for structuring the relevant information (Description of a Project Vocabulary (DOAP), 2004).
- *'Perpetual beta' and the lifecycle of laboratory or beta applications.* Musser & O'Reilly (2007) originally defined 'perpetual beta' as (web) developments or applications that are continuously updated and improved, rather than being terminated with a particular stable version or release. In the context of a library lab, this approach might mean that we periodically consider whether we should move an innovation

into a productive service, thereby abandoning its provisional nature. Otherwise, we might simply archive a beta application after a period.

3.1.2. Technical and engineering mindset

Software-based (rapid) prototypes exposed within a laboratory are often incomplete - if not inadequate - in terms of functionality, corporate identity, robustness, topicality and relevance of data. They typically reflect the original research work and, because of their intermediate stage, do not expect or receive much attention from user feedback or service maintenance. In presenting the original innovation in an authentic style, they do not need to pay particular attention to the surrounding service portfolio, except perhaps for outdated or inaccurate data, to which a metadata-based service provider such as a library may be particularly committed. However, the original contributors to an innovation may adopt technical and engineering standards, particularly if they want their developments to be integrated into the organisation's technical and service landscape:

- *The software stack that is used.* Typically, in their role as inventors, researchers use the technical and programming environment with which they are most familiar, or which best supports the implementation task. However, this does not necessarily match the technology stack with which an organisation's services are built, maintained and operated - so a researcher's code is most likely to be rewritten, ported or at least refactored as an essential part of a transfer project (Tietz-Sokolsky, 2020).
- *General technology standards.* However idiosyncratic an inventor's software environment and "choices" may be, they may still adhere to general technology standards or paradigms in terms of, for example, operating system (e.g., UNIX derivative), web technology (e.g., HTML, CSS, JavaScript, server-side scripting), APIs (e.g., REST, OpenAPI), relational databases, or programming paradigm (e.g., object-oriented or functional).
- *Open source licensing and publishing* is a common issue and practice, but is often neglected when it comes to the explicit sharing and reuse of code. Many code contributors simply forget to properly license their code, effectively preventing its re-use (Bennett & Kosc, 2002). Without worrying too much about the legal details of licensing, a code contributor needs to make a fundamental decision about the terms under which his or her code will be shared or reused, using helpful tools such as ChooseALicense.[1] Essentially, the decision will be whether to be as permissive as possible by allowing even commercial use, or to prevent the latter by requiring a share-alike.
- The use of *Continuous Build and Integration (CI) workflows and standards.* A code contributor may be practising modern software management on her own, with no intention of sharing his code with anyone else. However, with a view to a future transfer scenario, it is always advisable to practise CI workflows and components to make it easier for other application engineers or DevOps to operate and maintain the original development.

As it is essentially self-organised, we can only think of the 'laboratory approach' as a first - and optional - step in the transfer of a technology, followed by another mandatory activity.

[1] https://choosealicense.com/

While running a laboratory ‘is about the process, not the final product’ (Phetteplace et al., 2013), the latter requires a different framework.

3.2. The transfer project approach

In relation to the laboratory scenario, this approach has two main characteristics and challenges: gatekeeping as the process of mediating a new technology to its recipients, and the integration of an innovation as a 'prime candidate' into a library's service portfolio. To achieve the latter, our transfer model usually requires the establishment of a transfer project, but with peculiarities that make each transfer project unique. Formally, each type of transfer project in our model has the same actors: a source in the form of a researcher or member of the laboratory, a receiver in the form of end users and/or library staff, and a gatekeeper who mediates between the other two actors and acts as a product owner or service manager. In addition, we can imagine a few more personas involved in the process, such as representatives from top management and hands-on workers, for example librarians, system administrators and software developers.

As agents of innovation and process owners, gatekeepers are primarily responsible for a transfer project once the basic decision to transfer has been made. This decision may be the sole responsibility of the gatekeeper, but in an organisational context it may also require the commitment of a library's top management, particularly if both the transfer and the ongoing operation of the innovations draw on other library resources. In terms of their role, we can think of a gatekeeper in two ways: On the one hand, this actor is responsible for the coherent integration of an innovation in a 'user-centric' and product-friendly way (product owner). On the other hand, it is also responsible for the smooth technical integration of the innovation in terms of software management and operations (process owner). As these two requirements and respective skills are quite different, it might make sense to divide them between two people.

The consolidation of an innovation in terms of a software prototype can involve a considerable amount of complexity, depending on the nature and maturity of the original innovation and the targeted service portfolio and environment. Based on our experience with service innovations, we can broadly distinguish three approaches to turning an innovation into a productive service or feature, sorted by increasing complexity and effort:

3.2.1. Data transfer

Most library services and innovations are based on content metadata, such as bibliographic or authority metadata, or structural metadata used for e.g. collections, or usage data in the form of e.g. citations. As a result, innovations in libraries often have as their primary goal the introduction of new or differently curated metadata, processed by software and algorithms. Examples are (automatically) extracted metadata for subject indexing (Golub, 2021; Kasprzik, 2023) or disambiguation and normalisation of metadata, e.g. by linking to authority data (Zhu, 2019). In these cases, the result is improved metadata that can be integrated into a library's bibliographic database or catalogue. As a result of a transfer project, the metadata is an integral part of the library's workflow and metadata infrastructure, residing permanently in, for example, a metadata repository and updated regularly. The software

used to create the metadata may also be the subject of a transfer project, but this is more likely to fall into the following category.

3.2.2. Service transfer

In contrast to the transfer strategy above, projecting an innovation into a (micro)service architecture means setting up an autonomous service that operates independently of the library's core services. Examples of this kind are services for querying user requests such as suggest services or recommender, which are not a mandatory part of the library's service stack, but only support a user's interaction with a primary library service. As such, these services are not fundamental to the standard library services, but merely support a user's interaction with a primary library service. According to the microservice paradigm (Lewis & Fowler, 2014), a transferred (micro)service is scalable and more flexible in terms of development and operation, as it does not necessarily have to conform to the default software stack used for a library's services. Therefore, it may give developers or service maintainers more freedom or flexibility in terms of technology choices, as long as the services are regularly maintained and deployed, e.g. through containers communicating via API or REST interfaces.

3.2.3. Application transfer

This is probably the first approach that comes to mind when we associate technology transfer with a project activity. It aims to deploy a new application as a service, including typical components such as a web interface, middleware or business logic, and a storage layer. Examples of this type are a visual interface for browsing collections or an application for searching within images. However, for the majority of libraries at least, this may be the less common scenario, as it would require a fundamental decision and commitment by library management, taking into account the overall resources of a library. Another reason is that new library services are often driven not by individual research and innovation, but by off-the-shelf software and cloud-based infrastructures.

It is important to note that, in the real world, an original research result can be transferred in many ways, not limited to those mentioned above. Moreover, the three views may overlap and mix; there is no determinism in technology transfer. For example, if we consider the introduction of a new optical character recognition (OCR) service, depending on its design, scope and architecture, such a service could fall under either of the first two approaches. The generation of additional (meta) data to be indexed for full-text search might qualify it for the first scenario. Instead, we could treat it as an asynchronous microservice running on its own technology stack, which would be more in line with the second scenario.

4. Case study

Since the introduction of research transfer at our institution, we have carried out several transfer projects, one of which has resulted in a regular service for automatic subject indexing using machine learning techniques (Kasprzik, 2020; Kasprzik 2023). Another transfer project will be described in more detail here to illustrate some of the approaches and challenges mentioned above. The original research project involved the design and

prototyping of both a database and an application for retrieving information about economics journals and their articles, mainly indicators of impact and popularity in terms of different metrics (Borst & Osorio, 2020). The intention was twofold, both practical and investigative: on the one hand, our researchers wanted to build a database specifically for collecting and integrating different journal metrics from scattered data sources (e.g. bibliographic databases, journal rankings, social media platforms). On the other hand, they wanted a tool to evaluate the criteria used by researchers and other stakeholders to judge the quality of a journal. In the first phase, a research assistant developed a prototype web application in the form of a dashboard that allows a user to query and filter information about journals and display it through different visualisations such as graphs, bubbles, maps and spider charts. To achieve this, he used the proprietary Tableau software[2] and fed it with various data organised either as spreadsheets or as a MySQL database.

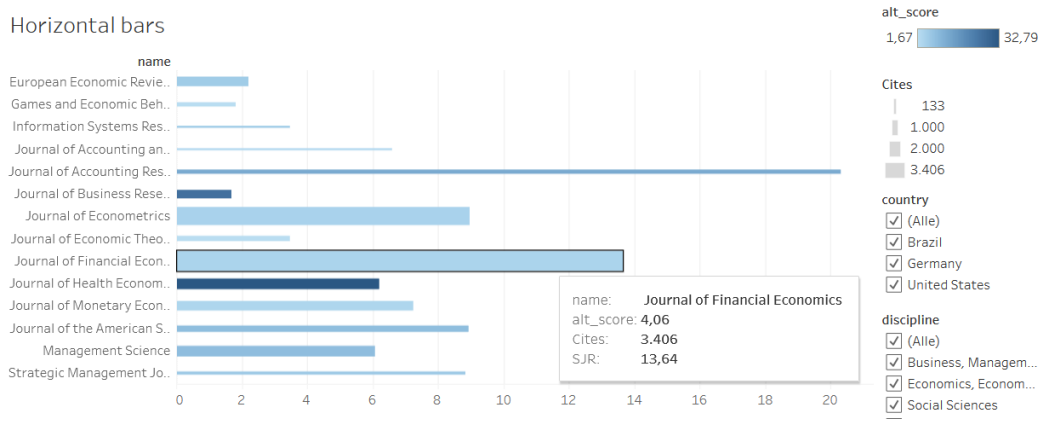

Figure 3. Prototypical visualisation of bibliometric indicators

After an internal review of the prototype, we took the decision to transfer the application into a productive service by

- creating an open source-based version of the application that could also be distributed locally and launched as a Docker container hosted on a Binder[3] server,
- integrating the bibliometric journal information into a subject portal for economics in order to enhance this already existing service.

Therefore, in a second step, we carried out a transfer project with the following actors and dispositions according to our diagram (Figure 1):

- *Source* = a research assistant and his supervisor who are primarily interested in experimenting with different visualisations for querying and displaying bibliometric information, the assistant being particularly familiar with the Tableau software suite.
- *Recipient* = generally library users, particularly economics researchers interested in publishing or reading articles from high quality journals. Other stakeholders include library staff responsible for journal acquisitions and publishers interested in the ranking of their products.

[2] https://www.tableau.com
[3] https://mybinder.org/

- *Intermediary* = a product manager responsible for the subject portal and its mediation to target groups. In addition, two software developers were involved in transferring the original application and integrating the journal information into the portal.
- *Source/recipient relationship* = the research assistant collaborated with the two software developers, mainly by exchanging data and investigating Plotly, an R library for visualising the data.

From a technical point of view, the main transfer activities were to clean up the data by formatting it or replacing journal identifiers with their textual titles, to introduce R for processing and displaying the data, and to package both the data and the application as a Jupyter notebook that a user or researcher could run locally. In terms of contextual knowledge, 'the transition required time spent getting to know R and its libraries, to learn how to create the kinds of charts and filters that would be useful for users.' (Borst & Osorio, 2020)

Since its deployment as a Jupyter notebook[4], several economists have evaluated the journal information system ('Journal Map') in a workshop organised by product management. As far as the subject portal is concerned, we have partially integrated the metadata into the journal article view, but we have stopped fully integrating and regularly updating it. We therefore did not achieve a complete transfer of data and services, but we did migrate the application to a technology stack that we internally recognised as maintainable.

5. Summary and outlook

Academic and research libraries are constantly striving to innovate their services, either by collaborating with external research partners or with colleagues in research departments. However, even when librarians and researchers share the same organisation, the transfer of research results in terms of software technology remains a challenge. Against the background of a general transfer model, we have outlined two approaches to such transfer: either by exposing the original research work as a beta application, prototype or demonstrator in a virtual laboratory, and/or by transferring the research result to a more sustainable service environment. We then depicted a case study to illustrate some of the typical challenges and operations involved in a transfer project, such as identifying the intended use cases, refactoring and deploying the original code according to common and in-house standards, and integrating it into a production service.

Our approach may raise a number of questions or concerns, two of which we will briefly address: First, it may be questionable how to adapt our transfer model for research results other than software artefacts, e.g. empirical or analytical results. This would mean operationalising these results and translating them into functional requirements or service requests from the point of view of the recipients. But how can this be done in a transparent and reliable way? Secondly, how to preserve innovations that may have been introduced on the basis of ephemeral insights or developments? Original research results, at least in terms

[4] https://github.com/f-osorio/jupyter/blob/master/jupyter/ZBW%20Journal%20Stats.ipynb

of software-based outcomes, may become obsolete, invalid or dysfunctional in a service environment that is constantly updated with software packages from communities, other library staff or vendors. The better we understand these processes, the more we can build a service and information practice that is continually improved by transferred research and innovation.

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