Understanding Open Source Adoption in UK Small and Medium Sized Businesses: Gap or Chasm?

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Abstract: *Open source software is a common component in modern computing systems of all scales. Recent data illustrates its flexibility, being the dominant software platform for both smartphones and supercomputers. In this paper, existing work relating to open source software adoption is critically evaluated, along with extant models used to classify it. Dominant technology adoption theories are also discussed, with shortcomings highlighted when applied to open source software environments. The paper then outlines gaps in the canon relating to small businesses, non-IT organisations and UK based studies.*

Keywords: open source software, small businesses, technology adoption, transition, barriers and drivers, modelling, TOE, TAM, IDT

Introduction

Open Source Software (OSS) typically combines zero acquisition cost with a licence permitting the program to be improved and re-distributed to third parties (Woods & Guliani, 2005). This contrasts with proprietary software which comes with strict licence conditions regarding use and distribution (Zittrain, 2004). The acquisition, upgrade and maintenance of proprietary software can account for a substantial part of a company's Information Technology (IT) budget (Kisker *et* al., 2010), particularly in specialist fields such as enterprise resource planning (Serrano & Sarriegi, 2006). While OSS solutions may not be as well-known as some proprietary software, they are the dominant form of software in many areas (e.g. supercomputing (Top500.org, 2014) and smartphone operating systems (IDC, 2014). However, use in some areas such as Small and Medium Sized Enterprises (SMEs) is unknown.

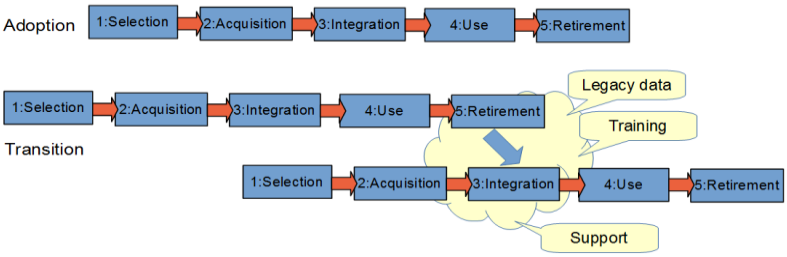
SMEs are private companies with less than 250 employees and a turnover not exceeding €50m (European Union, 2003). With 98% of UK businesses employing fewer than 50 people (Office for National Statistics, 2011), SMEs are a major driver of economic growth (Wennekers & Thurik, 1999). SMEs commonly have limited investment capital (Walczuch *et al.*, 2000), so the low up-front costs may make OSS appealing to them. Given the prevalence of SMEs and the potential for OSS use within them, this is an area worthy of academic interest.

This paper aims to show that:

- SMEs are overlooked by existing OSS adoption literature.
- Existing adoption studies make use of a mixture of IT and non-IT organisations limiting their generalisability.
- Common techniques relating to theories of technology adoption have not been applied to OSS and SMEs.
- The absence of a clear and practical adoption framework to support OSS adoption in SMEs.

Open Source Adoption and Transition
Most previous work uses the term adoption to describe the acquisition and implementation of OSS within organisations. However, this term is slightly misleading, as few organisations will be installing software for the very first time. It could more accurately be described as a transition from proprietary software to OSS, with the previous state providing an important back-drop, further complicating the process. Figure 1 illustrates the software deployment lifecycle (Shaikh & Cornford, 2011), adapted to show both adoption and transition. The upper row shows a simple adoption process with no previous IT system. The lower row illustrates transition, where the retirement of the *in-situ* solution needs to be synchronised with the integration of the new solution. However, for consistency with previous studies, the term adoption will be used throughout this paper when referring to the work of third parties.

Figure 1: Adoption vs transition



Terminology aside, OSS adoption is an under-represented topic in the academic literature (Aksulu & Wade, 2010; Mount & Fernandes, 2013). Some attribute this to the ease with which other aspects of OSS research can be carried out (Crowston *et al.*, 2006; Fitzgerald, 2011) but it is also likely to be due to the difficulty of gaining accurate data on both current usage levels and adoption/transition processes. Extant work quantifying OSS adoption focuses largely on its use (step 4 in figure 1) in public network infrastructure (e.g. Netcraft, 2014), usually because it can be measured easily by automated means. However, such software represents but a small subset of available OSS. This simple numeric measure is also silent on the processes (such as selection, acquisition etc.) that led to that use. Additionally, it indicates use only on public, not private networks networks.

Where software other than that used in public network infrastructure is considered, OSS usage statistics are commonly based upon downloads or website views (e.g., Vignoli, 2012). While some cite this as a way of measuring adoption (Crowston *et al.*, 2006), this can only truly be defined as interest in the software. It does not constitute evidence of installation or use of the software.

Neither of the above measures of use are grounded in theory, with little done to localise the data to geographical regions, organisation type or size. In instances where the broader adoption/transition picture is addressed, the majority of academic work focuses on large organisations (Hauge *et al.*, 2010; Spinellis & Giannikas, 2012), the public sector (Wichmann, 2002; Cassell, 2008; Rentocchini & Tartari, 2010; Gurusamy & Campbell, 2011; Shaikh & Cornford, 2011) or case studies of single package adoption (Ven *et al.*, 2006; Huysmans *et al.*, 2008).

SMEs are not large companies scaled down (Westhead & Storey, 1996). Existing studies dealing with the dissimilar environments of large and public sector organisations are therefore of limited use. Additionally, these do not address patterns of adoption, nor do they model the process of adoption. Understanding which patterns of adoption are more likely to lead to success is important to ensure a successful result. So, for example, is a transition programme for a back-office tool likely to be more successful than that of a user application? Can such generalisations be made?

One study that did address some aspects of adoption patterns studied a range of organisation sizes, with the majority being in the IT sector (Glynn *et al.*, 2005). While the range of sizes is an issue, the use of IT sector organisations also poses problems for generalisability. Most SMEs are not in the IT sector and have limited IT skills (Barry & Milner, 2002). Therefore, a sample composed entirely form IT companies may greatly affect the results. This lack of generalisability of previous studies means SME OSS adoption

patterns are not well understood.

Classifying Adoption and Transition

Glynn *et al.* (2005) and Fitzgerald (2011) both present models for classifying the stage of OSS adoption in an organisation. These cover most stages of adoption and table 1 shows how these align with each other and the software life cycle presented in figure 1. This alignment shows that the software lifecycle is incomplete, as it does not cover the early stages of awareness and exploration for possible software solutions. While the OSS specific models of Glynn *et al*. and Fitzgerald show the gradual movement from initial awareness to full adoption, these too are incomplete. OSS adoption can fail (Goode, 2005; Huysmans *et al.*, 2008), but neither model has a category for this. While it could be argued that abandonment covers this, abandonment after prolonged use is very different to early rejection. Prolonged use will leave a legacy of historical data, whereas early rejection will not. Another category absent from these models is one indicating a lack of awareness of OSS, a factor cited as hindering adoption (Morgan & Finnegan, 2007). This is a category into which many businesses may fit.

Stage transition is also a potential issue. The two OSS models imply a linear progression between stages, but this may not always be the case. For certain smaller deployments, it is possible that stages may be skipped. There is also a lack of detail on how organisations transition between stages. While Fitzgerald (2011) makes reference to an adoption process in his work, the model is at such a high level that it could only be of use conceptually. A richer model that takes into account factors driving and impeding transition, showing all possible stages and dealing with stage transition thresholds is needed. This, if detailed enough, could then be used by organisations to minimise the chance of transition failure.

Life-cycle Stage (Shaikh & Cornford, 2011)	Adoption stage (Glynn *et al.*, 2005)	Adoption stage (Fitzgerald, 2011)	Explanation of stage
	Awareness	Awareness/Interest	Key decision makers aware of OSS
	Interest		Organisation wants to know more about OSS
Selection Acquisition	Evaluation/Trial	Evaluation/Trial	OSS products have been obtained for testing and trial purposes
Integration	Commitment		Organisation has used a specific OSS product for a project or task
Use	Limited Deployment	Limited Deployment	Regular but limited use of OSS product
Use	General Deployment	General Deployment	Used for at least one large mission critical system
Retirement		Abandonment	The organisation has discontinued use

Table 1: stages of OSS adoption from previous literature

Applying the Concepts of Drivers, Barriers and Critical Success Factors

Transition drivers are specific factors that promote the adoption/transition to OSS. Research into the public administration of four European cities found major transition drivers were democratic principles, independence from vendors and openness (Cassell, 2008). Wishing to gain independence from vendors was common in studies of other European public bodies (Wichmann, 2002; Rentocchini & Tartari, 2010; Fitzgerald, 2011; Shaikh & Cornford, 2011; Kuechler *et al.*, 2013). This makes sense for public bodies, as the effects of being tied to a particular vendor are almost always socially undesirable (Zhu & Zhou, 2012), however it is unclear how this relates to the often conservative outlook of an SME.

Work dealing with transition drivers in SMEs is rarer and usually limited to the IT sector (Lundell *et al.*, 2006). Transition drivers for OSS vary from one sector to another (Lundell *et al.*, 2006), so, as previously stated, generalising from IT sector organisations to those outside it is not always appropriate.

Lower software cost has been identified by some as an important transition driver (Morgan & Finnegan, 2007; Ellis & Van Belle, 2009; Shaikh & Cornford, 2011). However, this is not universally agreed to be a major factor in all studies (Cassell, 2008). Despite this apparent uncertainty, the more comprehensive total cost of ownership has been investigated several times. These comparisons of OSS and proprietary solutions, are mostly vendor sponsored, such as: Microsoft (Bozman *et al.*, 2002; BearingPoint, 2004) and Red Hat (Gillen *et al.*, 2004). However, such studies are often environment specific and have no agreed definition of what constitutes total cost of ownership. Given this and the vested interest of the sponsors, the contradictory results should not be surprising. A more impartial view suggests the cost benefits of OSS tend to be seen in the medium to long term (Shaikh & Cornford, 2011), such as longer times between hardware upgrades (Morgan & Finnegan, 2007). However, the partisan vendor debate will continue until the current paucity of longitudinal studies (Hauge *et al.*, 2010) is remedied.

Barriers to OSS adoption have emerged in work with larger entities (Wichmann, 2002; Cassell, 2008; Hauge *et al.*, 2010; Gurusamy & Campbell, 2011). However, directly applying this to SMEs is difficult as their use of technology is different (Cragg & King, 1993). There has been some work on non-IT sector SMEs outside Europe (Ellis & Van Belle, 2009; Li *et al.*, 2013) which has uncovered a number of barriers to the adoption of OSS. However, it is important to understand the specific barriers to adoption in UK SMEs, as there is evidence to suggest these are not geographically universal. Barriers in Australia (Gurusamy & Campbell, 2011) have been found to be different to that of Europe (Wichmann, 2002), possibly due to nation level characteristics (Qu *et al.*, 2011). Additionally, data suggests adoption of OSS in the UK is lagging behind that of Europe (Howells, 2008). If barriers and drivers were generic across all geographies, this disparity would not be expected.

A major barrier to successful IT adoption is the identification and management of risks associated with IT projects. This is an issue for OSS adoption within SMEs (Ghobakhloo *et al.*, 2011) and may be why there is a tendency to for such organisations to adopt what their competitors are using (Salmeron & Bueno, 2006), ignoring alternatives such as OSS. Issues related to the management of risks associated with OSS adoption are also not well understood, with work in this area in its infancy (Franch *et al.*, 2013).

While there has been some work assessing the barriers and drivers of OSS adoption in SMEs, there seems to have been no attempt to identify the thresholds for success or failure of these factors. A Critical Success Factor (CSF) could be thought of as a driver or barrier for which there is a specific threshold at which it becomes significant. The concept of the CSF has existed since for over 30 years (Rockart, 1979) and the concept has been widely applied to other IT adoption situations (e.g. Ram *et al.*, 2013; Fu *et al.*, 2014). CSFs have been applied to the OSS development

process (Crowston *et al.*, 2012), but not using the methods espoused by Rockart. The authors can find no evidence that CSFs have been applied to OSS adoption, a major deficit in the canon.

Variance in drivers and barriers, and the thresholds at which they become significant, will require different strategies to avoid or mitigate them. It is apparent that inherent differences between IT sector SMEs, public bodies and large private sector organisations mean that an understanding of such factors in non-IT sector SMEs is at best vague.

Theories of Technology Adoption

Theoretical models, used to classify drivers and barriers to adoption, have been used to aid the understanding of how technology spreads between organisations. Three such models are investigated in this paper, each having been used for OSS studies at least once.

Gurusamy & Campbell (2011) have used elements of the Technology Acceptance Model (TAM) (Davis, 1986), considered the dominant model for adoption studies (Liao *et al.*, 2009), in work on OSS transition by Australian public bodies. TAM uses the concepts of perceived usefulness (PU) and perceived ease of use (PEU) to try to understand the potential for system adoption. In the study, PEU was found to be negatively correlated with adoption of OSS in the public sector (Gurusamy & Campbell, 2011). However, as this model only deals with perception, not fact, this barrier can be countered by more visible and targeted marketing and pre-adoption trials. It could also be argued that a driver such as lower cost, commonly (but not universally) associated with OSS adoption, does not fit easily within this model. While some might argue that this is a PU characteristic, it is at best a tenuous alignment, perhaps indicating that PU and PEU are not the only factors involved and that a richer model or framework is required.

Innovation Diffusion Theory (IDT) was developed by Rogers (1983) to help understand the speed with which innovations are adopted and spread. This uses a broader range of concepts than TAM, such as relative advantage, compatibility, trialability, formalisation and observability. On the surface, these seem to be a better fit for the factors that intuitively affect software transition (is the software compatible with existing data? Can we easily run a trial?), but some have argued that the two models have facets that are the same could be combined (Wu & Wang, 2005). Many IDT factors have been cited as drivers of OSS adoption (e.g. trialability and compatibility) (West & Dedrick, 2006; Morgan & Finnegan, 2007), perhaps indicating a more natural fit with this theory. Since its inception, IDT has been applied to both to IT adoption generally (Tung & Rieck, 2005) and to OSS in large European companies (Morgan & Finnegan, 2007). However, as previously stated, large organisations vary greatly from SMEs, so these results should be treated with caution by SMEs.

The Technology, Organisation and Environmental (TOE) model (Tornatzky, 1990) has also been applied to OSS adoption. This involves looking from the viewpoints of technology, the organisation and the operating environment to identify barriers and drivers. Van Belle and Reid (2012) use this model with large organisations to identify factors affecting adoption, but the high level of internal IT resource makes this dissimilar to an SME environment. Work with South African SMEs using TOE (Ellis & Van Belle, 2009) also outlined a number of important factors previously unknown. However, South Africa is politically and economically disparate from the UK. National level factors such as power-distance orientation and uncertainty avoidance have been found to affect OSS adoption (Qu *et al.*, 2011). Additionally, the presence of 25% of the sample being IT sector organisations means that these results may not be generalisable to UK and non-IT SMEs.

It appears that none of these models have been applied such that they are generalisable to the UK and non-IT SMEs. Additionally, none of these models provide a complete picture of the transition process. While they

provide a theoretical basis in which to ground drivers, barriers and CSFs, they are insufficiently rich to guide and shape the transition. In order to achieve this, a model will be needed which deals with critical transition processes in greater detail.

An Example Process - Software Selection

As can be seen from figure 1, the transition process requires the selection of replacement software. Selecting the most appropriate software from the wide range available is a major challenge (Wilkinson, 1995). Choosing the wrong software could lead to failure of the transition process (Howcroft & Light, 2008). Businesses of all sizes struggle to select software due to out-of-date selection methods and vested staff and vendor interests (Wilkinson, 1995). In some cases, the technology chosen by SMEs is based entirely on the degree to which external consultants are able to 'sell' the software (Howcroft & Light, 2008). This highlights the importance of environmental and human factors unrelated to business need and technical functionality and may be evidence of the idiosyncratic management typifying SMEs (Westhead & Storey, 1996).

As there are no sales staff and little marketing literature for OSS, other sources of information are needed to inform the selection process. Commonly, this takes the form of advice from staff who have previously used OSS (Ven & Verelst, 2008), but these are likely to be rare in non-IT SMEs. However, the software selection process is a multi-criteria decision making problem (Jadhav & Sonar, 2011) and as such can be made more systematic and repeatable. One of the earliest such methods developed for OSS was the Open Source Maturity Model (OSMM) (Golden, 2005). This uses the maturity, a complex qualitative measurement of quality, of an OSS project as a proxy for overall quality; something a typical business owner can easily understand. While this use is questioned by some (Taibi *et al.*, 2007), there is some evidence to suggest that more mature (in terms of age) projects offer a higher quality of software (Zhou & Davis, 2005). However, while some criteria used by OSMM are clearly proscribed (e.g. support maturity), others (e.g. product maturity) are subjective, leaving the user the job of defining what constitutes excellent and poor. This could lead to a wide variation in rating between those using the model for the same software.

Since OSMM, new methods have been devised including Open Business Readiness Rating (OpenBRR) (OpenBRR, 2005) and Qualification and Selection of Opensource Software (QSOS) (Semeteys, 2008). These use a wider variety of specific metrics to generate a composite score of 'readiness'. Both tools have their detractors, with criticisms of subjective metrics aimed at OpenBRR (Taibi *et al.*, 2007) and ambiguity of metric measurement in OpenBRR (Deprez & Alexandre, 2008). It could also be argued that both systems are complex and require a level of knowledge to utilise that would not be found in an average non-IT SME, or in many cases a large IT department.

Additional OSS selection tools have been developed, with Stol and Ali Babar (2010) identifying 20 in their work. Of this 20, only half are accompanied by a method outlining required activities and many have not undergone real-world validation (Stol & Ali Babar, 2010; Adewumi *et al.*, 2013). While Glott *et al.* (2010) evaluate two such tools, this still leaves many untested. Since their proposal, some of these tools appear to have been abandoned having dormant websites (e.g. OpenBRR), or with required documentation being hard to obtain (e.g. QSOS). Many also require a level of computing knowledge exceeding that found in a non-IT sector SME.

Despite initial promise, the proliferation of OSS selection tools and the lack of clear data regarding their efficacy is an issue for not just SMEs, but all organisations. It could be argued that the selection and use of such a tool is more difficult than the selection OSS itself. OSS selection represents only one process in the larger software life cycle and is one that has arguably received the most attention. Choosing the best software available will not guarantee successful transition on its own, but may help minimise some acceptance barriers. Many other

processes need to be identified and considered in detail to maximise the chance of success.

Conclusions

While OSS is a popular topic for academics, only a small amount of this work relates to OSS adoption and transition (Aksulu & Wade, 2010; Macredie & Mijinyawa, 2011; Mount & Fernandes, 2013). Of this work, most focuses on large corporations or public bodies. As SMEs are not just smaller versions of large organisations (Westhead & Storey, 1996), little of this can be applied directly to SMEs. Extant work relating to SMEs utilises a mixture of IT and non-IT, or solely IT sector organisations. However, as SMEs generally have limited IT knowledge (Gelinas & Bigras, 2004) these represent a special case. Such knowledge limitations and tool proliferation may prevent SME use of OSS selection tools, hampering the identification of suitable software.

Commonly used information systems techniques used in adoption/transition have not been applied to OSS in SME. Where technology adoption theories (such as TAM, IDT and TOE) have been used, they again look at non-SME cases (Gurusamy & Campbell, 2011), or disparate economic and political situations (Van Belle & Reed, 2012). Similar criticisms can be levelled at driver and barrier studies (Wichmann, 2002; Cassell, 2008; Ellis & Van Belle, 2009; Hauge *et al.*, 2010; Gurusamy & Campbell, 2011; Li *et al.*, 2013). Other tools such as critical success factors appear not to have been applied to OSS adoption at any level.

Given the above, it appears that there is a large gap in adoption/transition research relating to OSS. Questions that need answering by future work include:

1. A detailed model of transition processes and how they relate to OSS and SMEs (from section 2);

2. The construction of a more accurate theoretical framework for OSS transition in organisations, focussing on UK non-IT SMEs (from section 3);

3. An understanding of barriers and drivers for OSS transition for UK non-IT SMEs (from section 4);

4. An understanding of the critical success factors for OSS transition, especially, but not limited to, UK non-IT SMEs (from section 4);

5. A full, critical analysis of OSS selection tools form the point of view of a non IT UK SME (from section 6).

Once these issues have been addressed, a framework that is practically applicable for SME adoption of OSS can then be devised.

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