Structural Change and Economic Dynamics 23 (2012) 137–150

Contents lists available at SciVerse ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/sced

Technology, property rights and organizational diversity in the software industry

Fabio Landini*

Department of Economics, University of Siena. Pzza San Francesco 7, 53100 Siena, Italy

ARTICLE INFO

Article history:
Received 14 March 2011
Received in revised form 13 January 2012
Accepted 14 January 2012
Available online 25 January 2012

JEL classification:
C73 (evolutionary games)
D23 (transaction costs
property rights)
L17 (open-source products and markets)
O34 (intellectual property rights)

Keywords:
Software production
System design
Institutional diversity
Transaction costs
Evolutionary games

ABSTRACT

Why do open- and closed-source productions co-exist? To address this question, the paper studies the viability of distinct systems for software development. The model shows that: (a) for low design costs of modularity, both open- and closed-source productions are viable systems; (b) closed-source production is more likely to be adopted the greater the expected rents on software; and (c) production efficiency is not a necessary condition for the stochastic stability of a system to obtain. These three results can shed light on the emergence of organizational diversity in the software industry. The paper adds to the literature in three ways: first, it considers property rights and technology as endogenous variables in the process of system design; second it argues that in producing software multiple equilibrium designs may exist; and third, it shows that, in because of high rents and low design costs of modularity, production inefficiency can be persistent.

1. Introduction

In the software industry there presently exist two distinct ways of organizing production. On one hand there exist closed-source production, which relies on exclusive copyright claims, hired workforce and hierarchical coordination. On the other open-source production, which combines non-exclusive copyright claims, (mainly) unpaid work and peering-based coordination. Although both forms of production have existed since long time in the software industry,[1] none of them seems to effectively prevail. On the contrary, open- and closed-source productions tend to co-exist in most market segments.[2] This is clearly the case, for instance, in the market for web servers, where the competition between Apache (open-source) and Microsoft Web Server (closed-source) is more

* Tel.: +39 0577 232661; fax: +39 0577 232620.
E-mail address: landini4@unisi.it

[1] The free sharing of software among programmers (mainly working for public institutions such as universities) was an established practice in the early 70s, and it has survived side by side to the production of proprietary software all the way through the present days. On this point see Lerner and Tirole (2002, 2005) and McGowan (2001).

[2] For detailed information on the trend of market shares within the distinct market segments see: Netcraft, web server survey, July 2010. URL http://news.netcraft.com/archives/2010/, last time checked: 29th of July 2010. NetApplications, Top browser share trend, 2010 http://marketshare.hitslink.com/browser-market-share.aspx?qprid=1, last time checked: 29th of July 2010. Gartner Inc., competitive landscape: mobile devices, 1q10, 2010. URL http://www.gartner.com/DisplayDocument?doc_cd=200946l_ref=g_rss, last time checked: 29th of July 2010. For data on both database and desktop operating systems see David A. Wheeler (2007), Why Open Source Software/Free Software (OSS/FS, FLOSS, or FOSS)? Look at the Numbers! URL http://www.dwheeler.com/oss_fs_why.html, last time checked: 16th of August 2010.

0954-349X/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.strueco.2012.01.003

than 15 years long. A similar trend can be observed in the market for web browsers, where Internet Explorer (closed-source) has been steadily competing with Mozilla Firefox (open-source), and now also with Google Chrome (open-source). An almost equivalent situation exists in the market for database, with MySQL (open-source) competing against Oracle and SQL Server (closed-source), and in the market for mobile and desktop operating systems, with iPhone, RIM and Windows Mobile (closed-source) competing against Symbian and Android (open-source), and Microsoft Windows (closed-source) competing against GNU/Linux (open-source). Overall, looking at these as well as other market segments (e.g. office suites, finance and accountability packages, mail servers), it seems that for most part of the last two decades open- and closed-source software packages have simply co-existed in the market.

From the perspective of the standard organizational economics literature—e.g. Williamson (1985), the sustained co-existence of open- and closed-source productions is somewhat puzzling. According to this view, in fact, for any given set of available technologies, systems of production based on relatively inefficient allocations of property rights should be less likely to be adopted than more efficient ones, and thus a tendency towards organizational uniformity should emerge (at least for technologically equivalent products). In the software industry, on the contrary, we observe that for almost any kind of software package, two systems of production based on different property rights regimes co-exist. Why, then, do open- and closed-source productions co-exist? When both systems are effectively viable, what leads an organization to adopt one type of production rather than the other? Does this choice always entail that production efficiency is achieved? These are the main questions addressed in the paper.

The paper takes a system design approach to study software production. A system design is defined as a specific combination of two domains: technology and property rights. Both domains are assumed to be endogenous relative to each other, in the sense that technology is designed in order to adjust to the characteristics of property rights and *viceversa*.[3] On this basis, the model focuses on the decision-making dynamics leading to the adoption of a particular system design, and not on actual production. Although such an approach is highly abstract, it offers a useful representation of the complementarities that may exist among distinct design domains. The model shows that: (a) for sufficiently low design costs of modularity, both open- and closed-source productions are viable systems for software development; (b) when both systems are viable, closed-source production is more likely to be adopted the greater the expected rents on software; and (c) production efficiency is not a necessary condition for the stochastic stability of a system to obtain.

These three results, together with the widespread diffusion of digital technologies in the mid '90s, may offer an explanation for the exceptional degree of organizational diversity that we presently observe. The intuition is an analogy with the process of biological speciation. Acting as an exogenous shock, the diffusion of digital technologies has suddenly enlarged the set of software packages for which both open- and closed-source productions became viable systems. In consequence of the complementarities existing among distinct design domains, however, some organizations faced important constraints in the process of adapting their system to the new environment, and divergent trajectories of organizational speciation have emerged.[4] Only the organizations that, in because of low expected rents, lose little by shifting to open-source production were in the position of actually making the move, while the others got locked into the old system. As a result open- and closed-source productions have increasingly co-existed.

In the literature on free/open-source software (FOSS) several works have investigated the viability of open-source production from both a theoretical and empirical point of view—see Benkler (2002), Johnson (2006), Baldwin and Clark (2006), David and Rullani (2008), von Hippel (2007) among the others. Significant emphasis, in particular, has been placed on the role and functioning of on-line communities of developers—see Lerner and Tirole (2002), David and Shapiro (2008), Lakhani and Wolf (2005), Lakhani and von Hippel (2003), den Besten et al. (2008) and Shah (2006). Less attention, however, has been paid on the effective co-existence of alternative systems for software development, and on the factors leading to the adoption of one system design when multiple options are available. This paper is explicitly aimed at filling such gap.

The paper is also related with the more general literature on the evolution of economic diversity (see Pagano and Nicita, 2001). The latter includes the evolutionary theories of the firm (Nelson and Winter, 1982) as well as the comparative studies on institutions and their emergence (Aoki, 2001, 1998). In this respect the paper presents one of the first attempt to apply the analysis of institutional diversity to the case of software production. For a similar approach see Baldwin and von Hippel (2011).

The structure of the paper is the following. Section 2 defines the concept of system design, and characterizes the domains of technology and property rights. Section 3 presents the model. Section 4 studies the asymptotic stability of the equilibrium designs. Section 5 transforms the decision-making dynamics defined in Section 4 into an ergodic process and studies stochastic stability. Section 6 discuses the model's results and uses them to explain the emergence of organizational diversity in the software industry.

2. Technology, property rights and system design

A simple definition of a system for software development can be based on two domains: the first is technology (T), i.e. the technological characteristics of the resources used in software production; the second is property rights

[3] The system design approach adopted in this paper is inspired by the analysis of cooperative human systems design outlined by Benkler (2010). For a similar focus on a two-dimensional system defined in terms of technology and property rights see Pagano (1993).

[4] On the concept of organizational speciation see Pagano (2001).