General Purpose Technologies and the Exploration-Exploitation Tradeoff

Abstract

In this paper, I propose a novel study to understand firm level strategy implications from the emergence of General Purpose Technologies (GPTs). Departing from the insight from the Industrial Organization literature on GPTs that technology firms without bargaining power may be able to shift to higher volume economies arising from GPTs'horizontal externalities, I build on the capabilities literature in strategy to nuance the argument as an exploration-exploitation tradeoff between the appropriation capabilities of the firm and the appropriability environment of the industry ecosystem.

Keywords:
Capabilities, Complementarity, Firm level strategy, General Purpose Technology

GPTs and the Exploration-Exploitation Tradeoff

"Are there such things as 'technological prime movers'?", ask Bresnahan & Trajtenberg (1995) in their article that highlighted that certain technologies may foster generalized productivity gains in an economy. Calling these technologies General Purpose Technologies (GPTs), they suggest that these technologies have the quality of being able to be applied to different products or industries are low adaptation costs (Rosenberg & Trajtenberg, 2004). The benefit of such innovations therefore propagates across markets and industries. Later literature in the economics tradition has suggested that GPTs are more likely to be developed by diversified firms, or when downstream markets are composed of many specialized users rather than a few large customers. In this paper, I review the literature on GPTs in economics and strategy, identify interesting questions for firm decisions regarding GPTs and then propose a study to address that question. In the section that follows, I review prior art on General Purpose Technologies as they apply to firms.

FIRM LEVEL IMPLICATIONS OF GENERAL PURPOSE TECHNOLOGY

Much of the prior literature on GPTs in the economics tradition has focussed on the industrial organization antecedents and consequences of GPTs. I highlight a few of the terms and insights from this literature in the following sections.

Dedicated technology vs. General purpose technology

GPTs are contrasted with dedicated technologies. While a general-purpose technology can be used for different downstream applications. In contrast, a dedicated technology necessitates high adaptation costs when it is applied in distant contexts or for vastly different purposes than for which it was produced (Rosenberg & Trajtenberg, 2004). The primary characteristic distinguishing them has been adaptation costs, and there seem to have been little work linking the capabilities literature in strategy to the topic of GPTs.

Complementarity of R&D investments

In this section, I discuss two types of externalities that arise out of the complementarity of R&D investments in an economy.

Vertical externalities The industry structure of GPTs are characterized by vertical externalities, in that the R&D investments of downstream and upstream sectors are complementary with that of the focal industry. When a technology or market shock improves the efficiency of an application sector, the higher efficiency induces a greater investment in invention in downstream sectors. This in turn raises the investment in invention of the upstream sector because of the complementarity. Vertical externalities are however not unique to GPTs, as they may also occur with dedicated technologies too.

Horizontal externalities A shock to a focal industry induces investments for improving the quality of GPTs by upstream industries. Additionally, the shock also induces improvements and investments in downstream R&D, particularly in other industries. This is a unique trait of GPTs

that a shock in one application industry may easily propagate to other industry sectors. Horizontal externalities are key in GPTs playing the role of 'technological prime movers'in an economy.

Stylized facts from economics literature

In this section, I highlight some of the stylized facts developed about industrial organization related to generation and propagation of GPTs.

Fragmented downstream markets GPTs are more likely to be licensed, when downstream markets are fragmented. This enables upstream technology firms companies to increase their rents by expanding their licensee base rather than relying on bargaining. The implication then is that GPTs are likely to be developed by diversified firms. They are advantaged by internalizing positive externalities, and can extract rents from distributed upstream and downstream firms.

Large downstream firms A policy implication of this is that that large downstream firms discourage the production of GPTs (Bresnahan & Gambardella, 1998).

Industries with many firms Industries characterized by many different firms or submarkets encourage the production of GPTs. This is because their scale is not large enough to develop a dedicated technology, and they are willing to buy GPTs even if the GPTs are more standard technologies, not perfectly suited to their needs, which then require adaptation costs. One would therefore expect to observe GPTs rather than dedicated technologies small market niches.

When do firms licence GPTs? Gambardella & Giarratana (2013) argue that firms are more likely to license GPTs when product markets are fragmented, that is, when they are characterized by different submarkets. When a technology is dedicated to a specific application, the seller can only sell it to buyers who want to use it for that application. However, if the seller also operates in that product market, they may not be willing to sell the technology to nurture a competitor Arora & Fosfuri (2003).

Summary of GPTs in economics literature

The GPT literature in the economics tradition has focussed more on industrial organization implications of GPTs and has not particularly addressed how heterogenous firms within an industry or sector may determine to generate rents from GPTs.

GPTs in strategy literature

While research on GPTs has been slow to take off among strategy scholars, prominent scholar David Teece has suggested that a related concept to the GPT that has been addressed in the strategy literature is that of a platform (Gawer & Cusumano, 2002; Teece, 2012). Unlike a GPT that is directly employed by firms in various industries, a platform innovation is a set of rules and infrastructure that allows a network of firms to compete in one or more industries, with resulting benefits to the platform owner. Examples include the Windows operating system, eBay?s auction site and Amazon's AWS cloud infrastructure. Teece also suggests that when such technologies are

embodied in a product rather than licensed, it may enable effects similar to GPTs since multiple industries may then be able to use it with minimal adaptation. One stream of work has explored factors that affect the propensity for markets to 'tip'to a single platform (Katz & Shapiro, 1994). For instance, markets are more likely to tip when there are supply-side scale economies and homogeneous demand-side preferences. Hosasain et al. (2011) show that platforms are more likely to tip when there are significant differences in vertical differentiation (or quality) but are much less likely to tip when they exhibit significant degrees of horizontal differentiation. The implication is that systematic differences in the structure of an ecosystem affect the likelihood that a single or multiple platforms will exist. Despite sharing similarities with GPTs, platforms are different in that they (or a key part of them) are typically both closely held and are not quite as wide ranging in impact as GPTs. A few studies have discussed interesting examples about the development of GPT and its implications for company strategy (e.g., Maine & Garnsey (2006); Thoma (2009)). Boudreau (2010) found that granting greater levels of access to independent hardware developers in the handheld computing systems sector produces up to a five-fold acceleration in the rate of new product development. In the following section, I explore opportunities to apply GPTs to firm level questions

Opportunities for strategy research

Prior sections have clarified that most academic literature on GPTs have been in economics and industrial organization traditions. Very little work on this has happened in strategy literature with the little that has being in Enabling Technology and Platforms Teece (2012). The opportunities to explore the question of GPTs for firm level decisions is therefore both vast and overwhelming. Nevertheless, I will attempt here to raise a question of interest to strategy scholars.

My point of departure from the economics literature is the recognition that one small specialist technology firm among a large number of other technology firms is able to switch the source of its rents from a poor bargaining position (due to poor market concentration) to one of high volume (a factor that the small firm can much better control, Gambardella & McGahan (2010)). While the option of competing out of a poor bargaining position is valuable, the economics literature itself unable to explain why any one particular firm may be able to do so, and if so what characteristics allow such a transition. This is the question, I address in my proposal in the following section.

RESEARCH PROPOSAL

I am going to pitch this as an Appropriation Capabilities vs. Appropriability Environment framework that determines if the appropriate strategy is to explore, exploit, explore and exploit or just trade (or stay away).

Bring in the following: Absorptive Capacity Dominant Design Network Effect Search (Broad search vs Focussed search) Complementary Assets

Research Question

THEORY

On the topic of the general hypotheses

Figure **??** lays out the average score charts for four agent-field combinations while enforcing the field to start in Right of Center (this is the same as saying $p^0_{0,F} = 0.75$).

Leading into H1a We do so since the scale is symmetric across the Center (C), any initial mapping

Hypothesis 1a: When the institutional field is open to influence, slow learning adversarial agents will raise overall performance higher than slow learning agents with a neutral orientation

Reference to Table 1

Insert TABLE 1 about here.

Leading into H2a This trend is confirmed further in Figure **??** where the learning rates of agents are increased even further to 'Fast'.

Hypothesis 2a: For the same initial outcome preferences, the overall performance score varies curvilinearly with difference in the rates of learning of the agent and the institutional field

Data and Method

What is the sample. Why is it chosen. How is it going to contribute. S

Dependent Variable

Degree of Exploration 0 - Exploitation, 1 - Exploration, 2 - Exploration and Exploitation, 3 - Trade

Independent Variables

Appropriation Capability

Appropriability Environment

Independent Variables

Moderating Variables

CONTRIBUTIONS

What do you contribute to each literature. Basically nuance.

LIMITATIONS

Suggest how this study may help inform the literatures that it is drawing from, and the interesting research avenues it will open up. Discuss level of generalizability.

SUMMARY

Recap and motivate interest in framework, in theoretical value as well as in the particular empirical setting.

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TABLE 1: Firm choices in adopting to general purpose technologies (GPTs)

Appropriation Capabilities	Appropriability Environment: Restrictive	Appropriability Environment: Munificent
Weak	**Forced Exploration or Exit** **Rent is uncertain**	**Trade** **Entrepreneurial Rent**
Strong	**Exploit** **Ricardian Rent**	**Explore and Exploit** **Schumpeterian and Ricardian Rent**