

# **The Adoption of Core (Upstream) Technologies in Consumer Markets**

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## THE ADOPTION OF CORE (UPSTREAM) TECHNOLOGIES IN CONSUMER MARKETS

Most core technologies are developed in the higher tiers of supply chains (industry networks) through a portfolio of risky projects. In competitive supply chains such upstream firms hope to recover their costs and to profit by selling their above-the-market capabilities at premiums to downstream firms. Eventually, some downstream firms use these core technologies to improve their products to collect higher premiums from the consumer markets. Consumer markets indirectly finance the development of higher technological capabilities. It is, therefore, important for upstream firms to assess the desirability of the possible technologies they plan to develop. They need to assess how much of different technological capabilities are desired and what is the possible return at different levels along different capability dimensions. Not selling directly to consumers renders this especially harder for the upstream firms.

Consumers seem to enjoy higher capabilities in any product. Under competition across different firms and industries we find that they do not, nor are willing to pay for them. We show under what conditions some core technological capabilities are preferred over the others, how far the consumer markets desire the supply chains to invest in them and how much they are willing to pay for them.

**Model:** We consider an oligopolistic downstream tier firms selling directly to consumers and a potential upstream technology firm that is the leader on a certain technological capability dimension. This upstream technology leader provides a service or sub-assembly the downstream firms use to increase some visible capability of their products observable by the consumers (e.g., batteries for cell-phones with higher total power, high performance materials with higher durability for durable goods for the

consumers, faster and more reliable web content delivery for websites). The upstream technology leader charges a wholesale price as a function of different technological capability levels it may provide and the downstream firms also need to invest – simultaneously - to adopt the higher capability level by incorporating the upstream product or service to their own products. Depending on the new technological capability state of the tier, downstream firms simultaneously determine their prices to the consumers. The primary input to the model are the consumer demand functions and the demand factors they imply; and the downstream firms' adoption costs of the higher technology levels.

**Analysis:** We consider general demand functions and two specific demand function forms: linear and multiplicative with exponential terms; two-firm and more than 2-firm downstream tiers with and without symmetric demand functions, and investment cost factors, depending on the tractability of the problems in the two-stage game described above. We also employ numerical analysis to extend our results to more general settings.

**Primary Results:** There is an equilibrium capability state up to which the downstream tier is willing to invest as long as the better technology is provided at zero premium. We name this point as the – short term – “technological potential” of the downstream tier along the capability dimension in question. This is the upper bound on the maximum level of core technology that can diffuse to the lower tier and we use it to show its desirability. We show that core technologies which are differentiated sufficiently enough at the consumer markets which are served by firms with products of high idiosyncratic (design) values yet face demands which are sensitive to rivals' prices, are the technologies which are truly desired at higher levels. This also implies that even when the upstream firms have the bargaining power, monopoly downstream tier firms serving to their entrenched markets are not the best customers for core technologies. Technological potential can be also used to

understand why some seemingly desirable technologies are not truly desired – will not be compensated - by the consumer markets.

We construct a potential upstream technology leader's revenue as a function of the different capability levels, if it induces them onto a (symmetric) downstream tier, and investigate the effects of different downstream factors, including idiosyncratic valuations of the consumer products, length of the appropriation period of the higher capability, demand sensitivities of price and capability dimension in question. We find evidence that for a fixed level of downstream technological potential, the return to an upstream technology leader for better technologies tend to be higher from consumer markets that are “heated,” i.e., with downstream firms facing high demand sensitivities to each other's price and technology levels – as long as the price elasticity of demand is decreasing with respect to the capability in question. This revenue graph also provides another explanation to why a significant portion of already created upstream technologies may be held up in the upper tier and not sold to the downstream firms.

Our results have managerial implications for technology investors in project selection and determining investment amounts; and for governments (and inter-governmental organizations) in identifying more targeted policies that depend on the nature of core technologies to encourage competitive consumer markets to finance them.

**Keywords:** Product Innovations, Supply Chain Management, Core Technologies, and Technology Diffusion.