國立政治大學九十 二 學年度研究所(博/碩)士班入學考試命題紙 第 全 頁

考試科目	農業經濟學	所別	科管所	考試時間	月 日 星期 上/下午 第 節

答題請儘量輔以圖表或方程式來說明

一、（20%）需求函數與供給函數是如何由生產函數及效用函數推導出來的？

二、 (20%)

（1） 在經濟學中，如何定義「技術」及「技術進步」？

（2） 全自動紡紗機，半自動紡紗機及手動紡紗機可以同時是最有效率的技術嗎？爲什麼不是？爲什麼是？

（3） 廠商該如何選擇最有經濟效率的生產方法呢？

三、(20%)

河流的上游有一養豬場，下游有一遊樂場。Q 是養豬的頭數，養豬的邊際成本是 MC = Q，邊際效益 MB = 60 — Q。遊樂場因著豬場排出的污水所要負擔的邊際處理成本是 SMC = 2Q。請問：(30)

（1） 如果養豬場只考慮自己的利益，他會養幾頭豬？

（2） 如果同時考慮遊樂場所受到的影響，應該要養幾頭豬？

（3） 如果將河流的水權判給養豬場，依據寇斯定理(Coase Theorem)，在交易成本可忽略的情況下，養豬場會養幾頭豬？爲什麼？

（4） 同理 如果將河流的水權判給遊樂場，養豬場會養幾頭豬？爲什麼？

四、（10%）

規模經濟與學習曲線是相關或獨立的現象？規模報酬遞減就不會有規模經濟的現象嗎？

五、（30%）

假設產業中的每一個廠商有相同的邊際成本曲線 MC = c，產業的需求曲線是 P = a – bQ。請問在以下各種市場結構下，均衡的價格 P、產業產量 Q、各個廠商的產量及利潤 分別是多少？

（1）Cournot 雙占 （2）合作雙占 (3) Stackelberg 雙占

（4）哪一種市場結構經濟效率最高？爲什麼？

（5）爲何廠商總是有動機想要合作勾結？

備考	試題隨卷繳交

命題委員： -127- （簽章） 92 年 5 月 9 日

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國立政治大學九十 二 學年度研究所(博/碩)士班入學考試命題紙 第 P-1 頁

考試科目	科技與文獻評析	所別	科管所	考試時間	月 日 星期 上/下午 第 節

請閱讀所附五篇文獻並一一申論下列問題：

一、何謂企業生態系統？Wal-Mart 如何建構此一生態系統、且持續成爲領導者？此一生態系統包含哪些成員？（20%）

二、請說明 CISCO 所構築的 MRP System 及 Autotest system？是不是可用企業生態系統來說明？CISCO 的核心能耐是什麼？CISCO 如何將其併購公司的供應商整合至其系統裡？（20%）

三、請詳述爲何新藥發展如此昂貴？發現新藥的基本原則是什麼？每個階段爲什麼要花費那麼多時間？製藥業面臨的產業環境有什麼特性？（20%）

四、從這篇書評來看，你覺得 the Gift of Athena 這本書如何詮釋「經濟成長」的理由？它與一般論及經濟成長的觀點有何差別？ "Propositional Knowledge" 與 "Prescriptive Knowledge"，從科技創新的學理與實務上來看，各代表什麼樣的含意？兩者間的實質關係可能爲何？（20%）

五、從 Napster 的敗訴可學到什麼教訓？Apple 又可提供了什麼新的解決方案？唱片公司在這過程中，除了訴諸法律外，作了什麼努力？嘗試了什麼新的營運模式？（20%）

備考	試題隨卷繳交	第 9-1 頁

命題委員： -128- （簽章） 92 年 5 月 12 日

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考試科目	科技管理文獻討論	所別	科管所	考試時間	月 日 星期 上/下午 第 節

The Evolution of Wal-Mart: Savvy Expansion and Leadership

An ecological analysis of Wal-Mart reveals how a relatively small company, starting in a rural area of the United States, could turn its original isolation to advantage by creating a complete business ecosystem. Wal-Mart developed and continues to refine an offer that customers find nearly irresistible: low prices on a variety of brands as diverse as Gitano jeans and Yardman lawn mowers. Moreover, CEO Sam Walton managed the company's expansion superbly and increased bargaining power during the leadership stage.

THE BIRTH OF DISCOUNTING

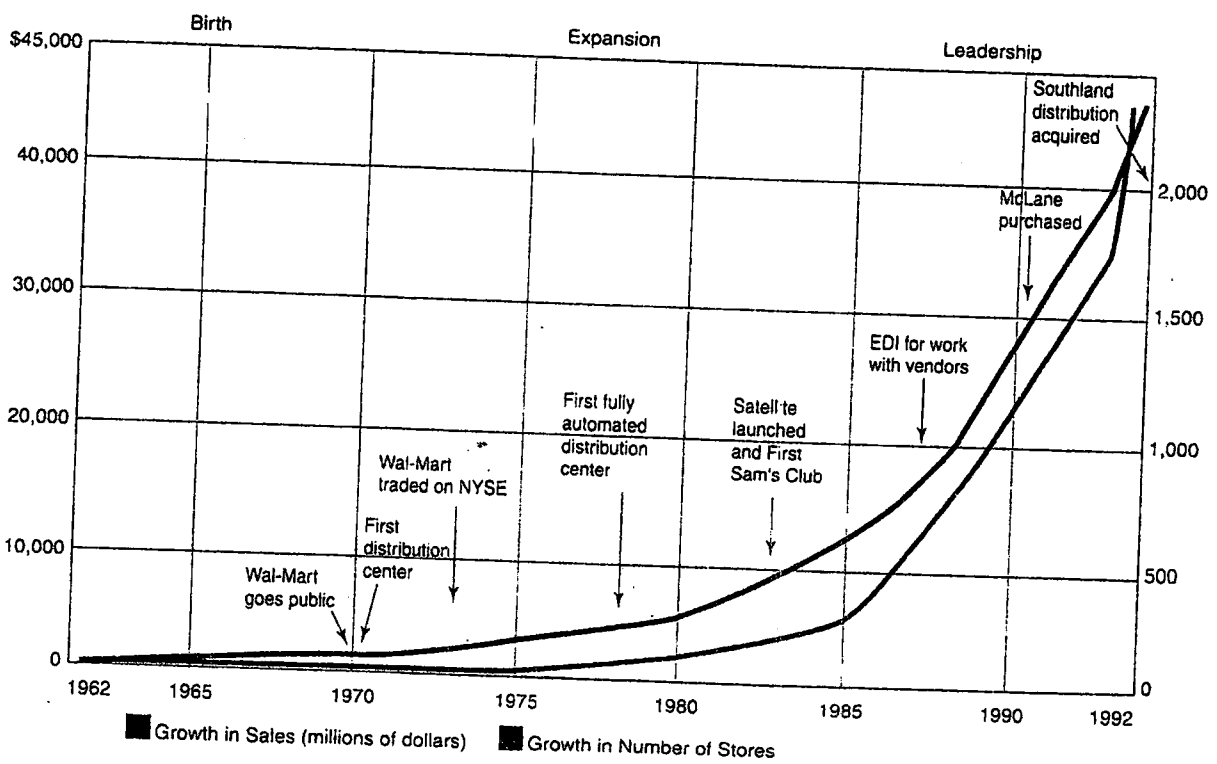
In the early 1960s, Kmart, Wal-Mart, and other discounters recognized that the Main Street five-and-dime was giving way to the variety store. And variety stores, in turn, were threatened by the large discount store. In order to buy a wide range of goods at low prices in one location, customers were increasingly willing to get into cars and drive to malls or other non–Main Street locations.

Kmart and Wal-Mart appeared on the discount scene at about the same time. The Kmart stores were actually owned by old-style S.S. Kresge, which reinvented itself as a suburb-oriented discount retailer, with big stores located near existing malls and towns of more than 50,000 people. Kmart stores carried items aimed at the lower end of suburban tastes.

By the late 1960s, Wal-Mart had worked out the basic structure of its own business ecosystem: Wal-Mart stores, which supplied a variety of well-known brands, were located in relatively sparsely populated areas. The company went into towns of 5,000 people, particularly where several of these towns might be served by one store. Wal-Mart products were up to 15% cheaper than those available in "mom-and-pop" stores.

While the original Wal-Mart locations could support one store, the customer population wasn't large enough to maintain two rival discounters. Thus once Wal-Mart established a store in a particular area and had beaten back weak local retailers, it was seldom threatened with future local competition from other discounters, including Kmart.

Wal-Mart Takes Off



備考	試題隨卷繳交 第9-2頁

命題委員： -129- （簽章） 92 年 5 月 12 日

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考試科目	科技報文獻評析	所別	科管所	考試時間	月 日 上 午 第 節 星期 下

EXPANSION: PLANNING FOR A CHOKEHOLD

Once its business strategy was up and running in a number of discount stores in the American South and Mid-West, Wal-Mart's top executives concentrated on developing organizational capabilities that would let it scale up successfully. They were obsessed with three things:

- Building a set of incentives that would ensure employee commitment to local stores, which led to a complex system of training, oversight, bonuses, and stock-purchase plans for workers.
- Managing communication and control of a network of remotely located stores, which required close monitoring of a carefully drawn set of measures that were transmitted daily to Wal-Mart headquarters in Bentonville, Arkansas.
- Setting up an efficient distribution system that allowed for joint purchasing, shared facilities, systematic ordering, and store-level distribution of a large number of different goods. This third obsession ultimately became Wal-Mart's trademark hub-and-spoke distribution system: warehouses served constellations of stores located no more than a day's drive from the center.

In 1970, Wal-Mart went public to raise funds for its expansion. That same year, the company built its first hub-and-spoke distribution center—embarking on a strategy of targeting a large geographic area, setting up a distribution center, and then populating the area with as many stores as the territory would support. Wal-Mart not only filled the needs of customers in small towns but also saturated entire regions, making it uneconomical for competitors to enter as either distributors or local store owners.

The number of Wal-Mart stores grew rapidly—from 32 in 1970 to 195 in 1978, when the first fully automated distribution center opened, to 551 in 1983, when Wal-Mart launched its own satellite, creating a communication network to keep in daily touch with its now far-flung empire.

LEADERSHIP: BUILDING BARGAINING POWER

By 1984, Wal-Mart's managerial agenda changed. What was in the birth and expansion stages a race to develop systems and conquer territory now became a concerted effort to build bargaining power. As the leaders of a highly successful and visible business ecosystem, Wal-Mart managers worked on continuing to assert the company's vision over other community members, including suppliers like Procter & Gamble, Rubbermaid, and Helene Curtis Industries.

First, Wal-Mart resisted the temptation to charge higher prices in the markets and regions it dominated. Instead, top managers still viewed each market as "contestable"—as a potential opening for rivals if Wal-Mart ceased to give the maximum possible value to customers. Continued customer leadership, in turn, enhanced the Wal-Mart brand and further cemented the company's place in the minds and buying habits of consumers. Wal-Mart's system of "everyday low prices," in which there's no need for weekly sales or special promotions, has now become a standard in discount retailing.

Second, Wal-Mart—now a very large and powerful channel to customers—started putting heavy pressure on suppliers to keep their prices down. Moreover, Wal-Mart compelled its suppliers to set up cross-company distribution systems to attain maximum manufacturing efficiency. For example, in 1987, Wal-Mart and Procter & Gamble reached an unprecedented accord to work together through extensive electronic ordering and information sharing between the companies. In return, Wal-Mart gives better payment terms than the rest of the retailing industry: on average, Wal-Mart pays its suppliers within 29 days compared with 45 days at Kmart.

Third, Wal-Mart continued to invest in and enhance its own fundamental economies of scale and scope in distribution. By the leadership stage, distribution had become the crucial ecological component of the Wal-Mart ecosystem. In fact, Wal-Mart's distribution chokehold has allowed the ecosystem as a whole to triumph over others like Kmart's. While suppliers, big and small, may chafe under Wal-Mart's heavy hand, it's also clear that most of them need this particular leader to survive. The graph "Wal-Mart Takes Off" is a testament to the company's dominance and bargaining power in the leadership stage.

Finally, Wal-Mart has extended its reach into adjacent territories and ecosystems. In 1983, Wal-Mart entered the membership discount market with its Sam's Club, which by 1992 included 208 clubs that contributed over $9.4 billion in revenues. In 1990, Wal-Mart incorporated another ecosystem by acquiring McLane Company, the nation's largest distributor to the convenience store industry. McLane, under Wal-Mart's control, now serves about 30,000 retail stores, including 18,000 convenience stores. And in 1992, Wal-Mart also acquired the distribution and food processing divisions of Southland Corporation. Southland operates a large chain of 7-Eleven convenience stores, and this acquisition added as many as 5,000 more 7-Eleven stores to the McLane/Wal-Mart customer base.

備考	試題隨卷繳交 第 9-3 頁

命題委員： —130— （簽章） 92 年 5 月 12 日

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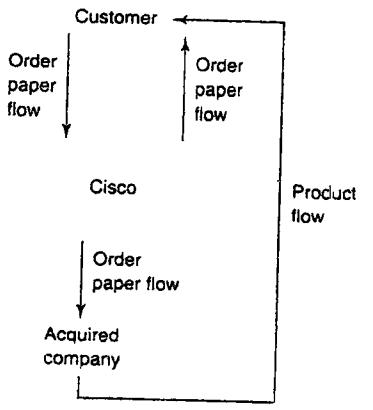
考試科目	科技管理文獻評析	所別	科管所	考試時間	月 日 星期 上/下午 第 節

Mandatory Manufacturing Integration Steps

ASSIGN EACH OF THE ACQUIRED COMPANY'S PRODUCTS A NEW CISCO PRODUCT NUMBER

Cisco assigned a new product number to each of the acquired company's products that would be entered into Cisco's MRP (manufacturing resource planning) database. At the initial phase, there would be no other details on the product (e.g. parts, cost data) in the database, so a transaction could not be fully conducted electronically through Cisco's MRP database. Instead, if a customer placed an order for one of the acquired company's products, Cisco would transfer the order internally (by phone, email, or fax) to the acquired company's order desk for fulfillment. The acquired company would then make, test, and ship the product from its facilities. However, all of this was done behind the scenes; from the customer's perspective, they were dealing directly with Cisco. (See the following illustration.)

Order and Product Flow.



RE-CREATE THE BILL OF MATERIALS IN CISCO'S MRP DATABASE

The next step was to recreate the bill of materials for each of the acquired company's products into Cisco's MRP database. This involved a detailed part-mapping process whereby a team from Cisco's component engineering group would analyze each specific part that went into each product to determine if an identical part was already used by Cisco—and therefore already in the MRP database. The process involved an extensive review of each part's data sheet, since parts that seemed identical on the surface could be ever-so-slightly different in reality. If an exact match were found, then the part would be given the existing Cisco part's number. If no match were found, then the part would be given a new part number. Since it was a detailed and time-consuming process, often taking up to 90 days to complete, the detailed part-by-part mapping would not be done for those products that were slated for short-term production or end of life.

While the primary goal of the part-mapping process was to "get it done," a secondary goal was to identify opportunities to consolidate parts and vendors. Cisco's goal was to utilize existing, preapproved vendors where possible and minimize the growth of its parts database. In other words, if the acquired company was buying a part that was almost identical to one that Cisco was already buying from another vendor, the team would flag it as an opportunity for near-term substitution. However, since the overarching goal was to integrate the parts data into Cisco's MRP database, only the obvious substitution opportunities were identified during this process. As Crabb described it: "We'll take all the low-hanging fruit, but we don't try to do everything at this point."

CONVERT THE ACQUIRED COMPANY TO CISCO'S MRP SYSTEM

Once all the parts had been given Cisco part numbers, Cisco would convert the company over to Cisco's MRP system. Unlike some of its competitors, Cisco did not believe in running multiple MRP systems in parallel, instead, Cisco made it mandatory for acquired companies to convert to Cisco's MRP system. However, in some cases, Cisco would recommend that the acquired company keep its own MRP system in place for its short term production products or end of life products. Once the company had converted to Cisco's MRP system, Cisco had all the necessary infrastructure required to plan, build, and ship the acquired company's products. Typically conversion to Cisco's MRP system would take place within 90 days of close.

CONVERT THE ACQUIRED COMPANY TO CISCO'S AUTOTEST SYSTEM

Cisco considered its Autotest system—a software-based automated testing system that measured the functionality and configuration of products—to be an essential component of its overall quality control process. The system worked by running data from the manufacturing process through a set of test "scripts." The Autotest system analyzed the data and determined whether the product passed or failed the tests, and under what conditions. The Autotest system was networked to Cisco's MRP system, enabling it also to test final product configuration to ensure that it matched the customer's order. Since Cisco sold many built-to-order, highly configurable products, there were numerous opportunities to make mistakes. The Autotest system gave the operator an almost foolproof way to ensure that the right product was being shipped to the customer. Cisco's external factories and subassembly contractors were also networked into the Autotest system.

If Cisco decided to continue operating an acquired company's plant for an extended period of time, then Cisco would require that the Autotest system be implemented in the acquired company's manufacturing facility. To set up the Autotest system, the integration team had to first determine whether the company had a set of written diagnostics for each product, since diagnostics were needed to write the test scripts. If the company did not have written diagnostics—which was typically the case—then development engineers from the relevant Cisco business unit would work with engineers from the acquired company to write diagnostics for the Autotest system.

On average it took three months to get the Autotest system up and running in an acquired company; however, it could take

備考	試題隨卷繳交 第 9-4 頁

命題委員： -131- （簽章） 97 年 5 月 12 日

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longer in cases where the engineering department was making significant changes to product design. During the period in which the Autotest system was being set up, Cisco depended on the acquired company's existing test processes for quality control—usually a set of PC-driven tests that required an operator to enter the script coding, run the test, and watch the results on the computer screen. While these types of tests were adequate for a small company, they were prone to human error, which was why Cisco mandated conversion to the Autotest system. In the best case scenario, the implementation of the Autotest system would coincide with the ramp up in the acquired company's production volume.

EVALUATE SUPPLIERS

Cisco's supply operations (supply ops) group evaluated, approved, and managed suppliers for both Cisco and its acquired companies. To qualify as an approved Cisco vendor, the vendor had to meet predetermined financial and business criteria, such as:

- Cisco could represent no more than 20% of the supplier's business, so that fluctuations in Cisco's demand did not threaten continuity of supply,
- The vendor had to be in solid financial standing, and
- The vendor had to rate highly on a quarterly scorecard administered by Cisco which measured performance against a series of criterion, including on-time delivery, lead time, quality level, customer support, and cost.

Cisco's supply ops group began to evaluate an acquired company's suppliers during the due diligence process to identify any risks to continuity of supply following the acquisition. Within 30 days of close the supply ops group was expected to have developed a plan for how to handle the supplier base. The goal was to convert the acquired companies to Cisco suppliers over time. However, the desire to use Cisco vendors had to be weighed against the impact the conversion would have on the continuity of supply and the development time for new products—in addition to the cost of the effort. As a result, Cisco rarely made supplier changes for products slated for short-term production or end of life. For products slated for long-term production and new products, Cisco's supply ops group evaluated new suppliers using the same criteria used to add suppliers to Cisco's approved vendor list. Marc Beckman, senior manager of global supply management for electronic components at Cisco, explained:

> We want to be able to influence supplier selection decisions just like we do here at Cisco. On the other hand, we don't want to impact the acquired company's business in a negative way. If we can switch to an existing Cisco supplier without having an adverse impact on their business, then we do. If we think it will have a real adverse impact, then we won't make the switch; we'll approve the vendor, but only for that *particular* product. If it's a critical supplier for a new product and we're too far down the road on development to switch, then we'll evaluate the proposed supplier and analyze the risks on a case by case basis.
>
> One thing we are sensitive about is the effect our decisions have on suppliers who have been supporting the acquired company over a period of time. We will often evaluate the impact of switching suppliers on the existing suppliers, and if the impact appears severe, we will try to work out an arrangement whereby they can support the product for a period of time until they can readdress their customer base.

CONVERT TO CISCO'S OUTSOURCING MODEL

Cisco required that the companies that it acquired convert to its outsourced manufacturing model as well. There were essentially three levels of outsourcing: piece part assembly, board level testing, and final assembly and testing. As a rule, Cisco always outsourced the first two to contract manufacturers. They also outsourced the third—final assembly and testing—in the case of products fulfilled by external factories. If the acquired company were operating under a highly vertically integrated production model, Cisco developed a transition plan for outsourcing the piece part assembly and intermediate testing activities, at a minimum. However, for products slated for short-term production or end of life, Cisco would often leave their in-house manufacturing processes in place. Cisco had also explored the possibility of leveraging its contract manufacturers to produce, fulfill, and provide aftersale support for products slated for end of life—but had not yet tested this option. Cisco's goal was to have a comprehensive outsourcing plan in place within 90 days of the close.

DETERMINE PRODUCT LIFECYCLES

In order to determine how to treat each of the acquired company's products, the manufacturing group first needed to determine how long Cisco planned to manufacture and support each product. Due to their importance, a first pass at these decisions was typically made within 30 days of the close. In order to make these decisions, the manufacturing team carefully reviewed the business case underlying the acquisition. In some cases Cisco acquired a company for its current line of products—meaning that most of its products would be slated for long-term production. In other cases, Cisco acquired the company for its potential to develop next generation products, rather than for its existing products—meaning that many of the existing products would be slated for short term production or positioned for end of life. However, even if a product were slated for end of life, it would be phased out over time, rather than eliminated outright, since Cisco's goal was to assure continuity of supply to the acquired company's customers immediately following the acquisition.

EMPLOY AN ACCEPTABLE DEFECT REDUCTION PROCESS

Cisco required that a basic statistical process control mechanisms be put in place to track yield and failure data on a daily and weekly basis. While the Autotest system would ultimately produce these data, Cisco mandated that the acquired company have an acceptable process in place at the time of the close for charting the data—even if it were a manual process.

ADOPT CISCO'S FORECASTING METHODOLOGY

Following an acquisition, Cisco continued to depend on the acquired company to provide product booking forecasts, since Cisco believed that the acquired company was most familiar with the demands of its own customers and marketplace. However, the acquired company would submit its forecasts to Cisco's business unit–level marketing group to discuss and revise, if needed. Input from Cisco's business-level marketing group was essential since they had the experience to project the implications of lever-

continued

concluded

aging Cisco's sales and distribution channels on an acquired company's production volume. Since the forecast would ultimately be entered into Cisco's MRP system and drive production decisions, it was important to reach consensus on it. As a result, Cisco required that acquired companies adopt Cisco's approach to forecasting within 30 days of the close.

Cisco required both a monthly review as well as a transaction-level forecast, and was just as interested in the assumptions that were used to develop the forecasts as in the forecasts themselves. Cisco required that acquired companies adopt Cisco's "envelope of demand" methodology of monthly forecasting, which entailed providing a set of quantified upside and downside ranges to the forecast. As part of the forecast, the marketing group included detailed assumptions about what would need to happen to achieve the upside and downside forecasts (e.g., three accounts would need to sign contracts to meet the upside forecast) and they provided probability assessments for these scenarios. By providing analytical rigor behind a set of ranges to the forecast, the marketing group helped the manufacturing group determine the types and levels of buffers to set up in manufacturing.

ADOPT CISCO'S NEW PRODUCT INTRODUCTION (NPI) METHODOLOGY

Cisco required that the companies it acquired adopt Cisco's NPI process for its new product development where feasible (sometimes new products were too far along the development process to convert to Cisco's NPI process). On the day the deal closed, Cisco would make a determination as to which new products were early enough in their development cycle to convert to Cisco's NPI process, and within 90 days of the close, the NPI process would be implemented.

Note on New Drug Development in the United States

Stefan Thomke and Ashok Nimgade

In the early 1990s, the pharmaceutical industry was one of the largest and most profitable research and manufacturing businesses, with annual worldwide sales around $250 billion. The engine driving its growth was heavy investment in research and development. The top 50 pharmaceutical companies worldwide spent around $25.4 billion in R&D, or almost 16 percent of their sales.[1]

For each therapeutic drug developed in the United States, the sponsoring pharmaceutical firms spent over $250 million, and the average time to market was 14.8 years (an increase of about 40 percent over the 1970s).[2] Estimated costs included both out-of-pocket costs, time costs (i.e., forgone investments as a result of investing in R&D before any returns are realized), and costs of failed projects. Although differing accounting techniques lead to varying estimates, new drug development has undoubtedly been costly, with high failure rates.

 Professor Stefan Thomke and Research Associate Ashok Nimgade, M.D., prepared this note as the basis for class discussion. Some of the data presented is based on empirical studies conducted in the late 1980s and may have changed at the time of discussion.

[1] *Pharmaceutical Industry Summary,* Lehman Brothers (1996).

[2] U.S. Food and Drug Administration (FDA), "From Test Tube to Patient: New Drug Development in the United States," *FDA Consumer,* Special Issue (January 1995); J. DiMassi, H. Grabowsky, and L. Lasagna, "Cost of Innovation in the Pharmaceutical Industry," *Journal of Health Economics* 10 (1994); pp. 107–142.

Clearly, such war-level-like marshalling of resources, involving thousands of highly trained individuals spanning continents, represented a vast difference from the millennia-old practice of healing through herbs. Yet, the basic principles guiding drug discovery through the centuries have remained unchanged: optimum therapy should combine medical efficacy with minimal side effects.

Even after the synthetic chemistry revolution of the mid-nineteenth century, modern drugmakers, like their forebears, continued turning to nature for clues. But where traditional herbalists might have used a mix of compounds found in a single herb, synthetic chemists attempted to isolate the solitary "active ingredient" from a plant (such as aspirin from willow). At the very least, this would allow for patentability.

To get this all-important patent and to develop new drugs more effectively, however, modern drug companies follow a very systematic R&D and approval process. What follows is a description of the steps that were required in the late 20th century to get a drug from the lab bench through the U.S. Food and Drug Administration (FDA) approval process—the world's most stringent drug approval process. Glaxo-Wellcome's anti-migraine drug sumatriptan (also known as Imitrex®) will be used to demonstrate new drug development challenges facing pharmaceutical firms. (See Exhibit 1.)

PHASES OF NEW DRUG DEVELOPMENT

Basic Research (About Two Years)

Classical drug discovery as practiced through much of the 19th and 20th centuries involved the initial screening of plants, microorganisms, and other naturally occurring substances in order to find a "hit" or "lead" compound. Typically taking place in test tubes (in vitro) and lab animals (in vivo), this initial screening allowed for quicker, cheaper and safer testing than that using humans. In essence, the process was like trying to find, through trial and error, the right molecular key to open up a biochemical lock within the body. The keys were often found in odd places. For instance, cyclosporin, widely used to treat organ transplant patients, was isolated by a Finnish researcher from a mud extract. Perhaps a more common place to initiate massive screening programs, however, was in the vast collections, or libraries, of hundreds of thousands of compounds that most pharmaceutical companies retained over decades.

With this broad screening strategy, an average of only 1 out of every 10,000 compounds screened would eventually make it to the market. One strategy to beat these astronomical odds was to develop "me-too" versions of preexisting drugs—for example, there are more than 200 antibiotic versions, or analogues, of penicillin, which was discovered in the 1920s.

Yet another way to beat the 1:10,000 odds and create more revolutionary drugs involved understanding much more about the molecular locks (receptors) where therapeutic compounds were thought to act. But "disease processes are complex and involve a sequence of events," according to Rhonda Gruen, Ph.D., of Hoffmann-LaRoche.[3] "If you want to intervene in the disease process, you try to break it down into its component parts. . . . You would then select a particular step as a target for drug development." But even with this reductionist approach, which relied on newer technologies such as genetic engineering, the goal of creating drugs based on completely deterministic principles eluded scientists.

Regardless of which strategy was used to identify lead compounds, drug development involved painstaking iterative research, with organic chemists making analogues or modifications of existing leads. A single experienced chemist could generate around one new compound every 7 to 10 days, at a cost of $5,000–$10,000 per compound. This stage of the process could consume 124 chemist-years[4] and represented a critical path activity—a place of high leverage for speeding up the drug development cycle. Even newer methods of rapid drug compound generation, such as combinatorial chemistry, were carried out in conjunction with this careful, handcrafting of molecules at vital steps.

Pre-Clinical (Biological) Screening (About Three Years)

Traditionally, out of 10,000 starting compounds, only 40 might make it to the next stage of preclinical testing. The preclinical trials involve animal testing to assess safety as well as to gather data on biological effects of drug candidates. Attention is particularly focused on the absorption, metabolism, and excretion of the drug in animals in order to find clues about what to expect in human trials. (See Exhibit 2.)

Clinical Trials (About Six Years)

Drugs making it through the animal studies (now termed Investigational New Drugs, or INDs) are finally put through the most expensive and time-consuming regulatory hurdles: human clinical trials monitored by the FDA. On average, roughly 1 in 10 of all drug candidates passes these trials and reaches the market. Increasing proportions of the total costs occurred with each of the three successive phases are described below.

Phase I: Safety Trials, One Year In this initial phase, the drug is tested for up to a year on one to two dozen healthy volunteers who are well-compensated for their participation. Often, very high doses are administered to determine potential toxicities and safe ranges. This phase, however, also yields invaluable information on the absorption, metabolism, and excretion of the drug in humans. (See Exhibit 3.)

Phase II: Efficacy Trials, Two Years While Phase I marked the introduction of the new drug candidate into humans for the first time, Phase II represents the testing of the drug on human *patients*. This phase tests the drug candidate in up to several hundred volunteer patients based at participating hospitals. To ensure statistically relevant data, typically from this point onward in all human trials, a portion of the volunteers receives the drug while the others receive placebos, with the data-gathering clinicians themselves remaining ignorant ("blinded") about what each patient receives.

While this phase allows researchers to evaluate the drug's effectiveness, it also provides further information about adverse effects and optimum dosage levels. At the end of this phase, researchers confer with FDA regulatory authorities to determine whether to go on to Phase III trials. Roughly one-third of all drug candidates typically survive Phase I and II. (See Exhibit 4.)

Phase III: Long-Term Efficacy Trials, Three Years Phase III trials is by far the most expensive phase of drug testing, involving thousands of volunteer patients at hospital sites scattered around the country and even overseas. In Phase III, researchers monitor long-term drug use for safety and optimum dosage levels. By studying far more patients over a longer period of time than in Phase II studies, they can uncover subtler and more insidious side effects. Over one-fourth of drug candidates pass this hurdle and move on to the FDA review stage. (See Exhibit 5.)

FDA Review (About Two to Three Years)

The NDA (new drug application) represents a tribute to the 20th century pharmaceutical industry's data-generating capacity, with its contents running into hundreds of thousands of pages. The NDA includes data not only on each patient, but also on the company's plans for producing and stocking the drug. Not surprisingly, the FDA committee has historically taken two to three years to review the NDA and make recommendations about marketing the drug. (Fortunately, the trend toward computer-assisted NDAs has already started to reduce this rather long review process.) Often, the FDA and sponsoring drug firms work closely to iron out potential problems with the data or other technical problems.

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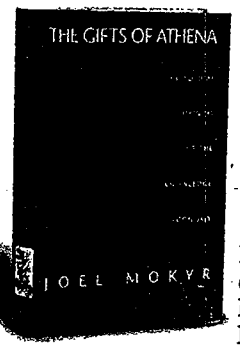
[3] *US Food and Drug Administration* FDA, "From Test Tube to Patient: New Drug Development in the United States," *FDA Consumer*, Special Issue (January 1995).

[4] R. G. Halliday, S. R. Walker, and C. E. Lumley, *Journal of Pharmaceutical Medicine* 2 (1992), pp. 139–154.

THE GIFTS OF ATHENA
Historical Origins of the Knowledge Economy
By Joel Mokyr
Princeton University • 359pp • $35

HOW EGGHEADS LAID THE GOLDEN EGG

From the fierce conflict taking place over federal budgetary questions, you might deduce that government actions are the key determinants of economic health. Yet, according to Joel Mokyr, the impact of fiscal policy pales in comparison with that of ideas and innovations. Indeed, there's barely a mention of taxes or deficits in Mokyr's fascinating, magisterial investigation into the wellsprings of modern economic growth and improved living standards, *The Gifts of Athena: Historical Origins of the Knowledge Economy*. What's truly important, he says, are the institutions, policies, and networks that generate and disseminate "useful knowledge."



Mokyr, a professor of economics and history at Northwestern University, is hardly a household name, but he's a key member of an influential group of economic historians that includes Douglass North, Richard Nelson, David Landes, Nathan Rosenberg, and Paul David. They have been grappling for years with the most compelling questions in economics: How does long-run economic growth occur? Why did the Industrial Revolution take place in the West? What factors explain why some nations are rich and others are poor?

Not surprisingly, *The Gifts of Athena* is a big-idea history book, a complex tale that interweaves science, technology, economics, sociology, and political science. Early on, Mokyr makes a distinction that frames the rest of his discussion: the difference between "propositional" knowledge and "prescriptive" knowledge. The first comprises beliefs about natural phenomena, such as scientific discoveries and practical insights into the properties of materials, heat, motion, and the like. Prescriptive knowledge is all about techniques—the manipulation of recipes, such as how to write a piece of software. The growing interplay between these two forms of knowledge, says Mokyr, transformed the world economy after the 1800s. "The historical question is not whether engineers or artisans 'inspired' the scientific revolution or, conversely, whether the Industrial Revolution was 'caused by science,'" says Mokyr. "It is the strong complementarity, the continuous feedback between the two types of knowledge, that set a new course."

The great divide in world history, of course, was the Industrial Revolution—or, as Mokyr calls it, the Industrial Enlightenment. To be sure, there was economic growth prior to the 1800s, and there were periods of remarkable innovation, as in medieval Europe and imperial China. But before the Industrial Revolution in the West, periods of growth would end in stagnation. Population growth caught up with raised agricultural yields, and fearful aristocratic and bureaucratic elites acted to block technological progress. What changed?

Mokyr focuses on scholars, philosophers, authors, scientists, and other intellectuals. In this era of scientific discovery, they believed in both comprehending and manipulating nature. But their ethos also supported the exchange of knowledge. The cost of gaining access to information plunged, thanks to the printing press, the formation of informal scholarly communities across European countries, and the creation of formal societies, such as the Institution of Royal Engineers.

While chronicling gee-whiz innovations and their impact on productivity, Mokyr shows how technology transformed the way people live and work. For instance, before 1750, most nonagricultural workers in Western Europe worked at home: The household and the plant were the same. Then came the rise of manufacturing, splitting the two. Behind the factory system was the fact that it proved cheaper to transport people to one location, where vital knowledge could be imparted, rather than to transmit such learning to their houses. Mokyr's book is mostly historical, but he does occasionally address issues of the present. For example, he sees the transportation/shared-knowledge calculus changing: "Modern communications and information technology are weakening the many advantages that the 'factory' has had over the household," says Mokyr, leading to telecommuting. This is hardly a new idea, but Mokyr brings fresh authority to the notion.

Like most other economists, Mokyr is a big believer in the benefits of openness, from freer trade among nations to shared technical information. He also understands the obstacles, and he pays considerable attention to an examination of the forces resisting technological change. He doesn't consider such opposition irrational. After all, when the steam thresher threatened the livelihood of 1830s British farmers and gentry, they rioted.

Similarly, an alliance of German blacksmiths, horse breeders, and railroad investors slowed the automobile's introduction in Germany, where it had been invented by Karl Benz and Gottlieb Daimler. Often, it is political power that determines whether a technology finds its way into the mainstream, and how quickly.

A couple of caveats: *The Gifts of Athena* is a dense and sometimes abstruse work. And even well-educated readers may grow peeved as they reach repeatedly for the dictionary. But when pondering questions of economic growth, I've found myself reflecting again and again on the book's wisdom. This is one that will stand the test of time.

BY CHRISTOPHER FARRELL
Farrell is a contributing economics editor.

HOW A SURGE IN THE EXCHANGE OF KNOWLEDGE FUELED GROWTH

備考	試題隨卷繳交 第 9-8 頁

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Online music

How to pay the piper

SAN FRANCISCO

As lawsuits fly, a new service offers a simple way to pay for music online

SINCE Napster arrived in 1999 to pioneer the unfettered exchange of music files over the internet, the record industry has responded with a two-pronged strategy. It has done its best to stop illegal file-swapping in the courts. And it has backed several subscription-based online music services, to provide a legal alternative to piracy. So far, neither approach has had much impact. But the events of the past few days may prove a turning point for online music, in the courts and in the market.

On the face of it, the legal battle is going just as badly as ever. Napster is gone, having been killed last year by a lawsuit launched by the music industry's "big five" record companies. But KaZaA, Grokster and other file-swapping services that have sprung up in its place are now even more popular than Napster was in its heyday, and are proving much harder to shut ▸▸

▸ down. New albums by Madonna (below), Radiohead and others are available online long before their official release; last week Madonna even resorted to flooding file-sharing services with expletive-carrying bogus files in an attempt to confuse pirates and boost sales of her new album, "American Life". Hackers promptly posted a free copy of the album on her website.

Napster lost in the courts because of a fatal flaw: it used central directory computers to keep track of the music each user was making available online so that other users could find what they wanted fast. Its parent company, which maintained these computers, was found guilty of "contributory infringement" of copyright. Its successors have avoided relying on a central directory computer. Instead, requests for a particular file are passed from one user's computer to another. This makes searching slower and less reliable, but lets the firms that make and distribute such programs (and profit by selling on-screen advertising) argue that they cannot be held responsible for the actions of their users. On April 25th, a federal judge in Los Angeles agreed, ruling that the firms behind Grokster and Morpheus, two popular file-swapping programs, were not guilty of contributory infringement, just as makers of video recorders are not responsible for the use of such machines for piracy.

This was a setback, but the record companies are having more luck trying to hit file-swapping networks in another way: by targeting users directly. On April 24th, another federal judge upheld a ruling in a test case that would require internet-access providers to reveal the identities of subscribers engaging in file-swapping when ordered to do so by a court. Verizon, an American telecoms firm that has so far refused to reveal the identities of two of its subscribers on privacy grounds, says it will appeal. The record industry aims to establish a precedent, so that it can force access providers to disconnect subscribers who are trading copyrighted material without having to go to court every time.

Even if it fails, the music industry has been quietly stepping up other efforts to pursue individuals by legal means—a risky strategy that could end up hardening some consumers' already-resentful attitude towards the record industry. On April 29th, the Recording Industry Association of America began sending messages to users of file-swapping programs who appear to be offering copyrighted music for download, warning them that they face possible legal action. The industry has also been clamping down on universities, asking them to warn students who use computers on campus of their criminal liability if they download music, and to wipe out illegally stored files.

So much for the stick. What of the carrot? Despite industry backing for several subscription-based online music services, such as Rhapsody, pressplay and MusicNet, response has been tepid. Lee Black, an analyst at Jupiter Research, estimates that such services have topped out at around 350,000 subscribers, compared with tens of millions of file-swappers. The appeal of subscription-based music services is limited for two main reasons. Rather than buy music outright, as they do on CD, users merely rent it for the duration of their subscriptions. And whereas a track on a CD (or downloaded from a file-swapping service) can be easily transferred on to a portable music player, or "burned" on to another CD, such transfers are either prohibited by online music services, or cost extra.

Now living in an immaterial world

So the launch on April 28th of a new online music service by Apple, a computer maker, could be a big step forward. The new service, called iTunes Music Store, rejects monthly subscriptions for a simpler model: each track from its 200,000-track library costs $0.99. Once purchased and downloaded, a track can be copied on to as many as three computers, burned on to CDs, and transferred on to Apple's popular iPod portable music-players. There is no need to buy an entire album just for one or two tracks. And Apple's boss, Steve Jobs, hopes that because there is no subscription fee purchasing a track will become an "impulse buy". Many people, he observes, happily spend $3 on a cup of coffee.

So far, the new service is available only in America, to users of Apple's Macintosh machines, which account for under 5% of personal computers. A version of the service for PCs running Microsoft Windows is planned for later this year. In effect, Mac users are acting as guinea pigs for a new way of selling music online. If it proves popular, the other paid-for online services will no doubt demand the same licensing terms from the record companies, and follow Apple's lead. Rumours that Apple would buy Universal, the biggest record company, have proved unfounded. Yet just as Apple pioneered the graphical interface in the 1980s, it could now blaze a trail for the music industry. If, that is, it can beat a free alternative... ■