External Affairs and
International Trade Canada

POLICY STAFF PAPER

NO. 93/12

OPTIMAL PATENT TERM AND TRADE: SOME CONSIDERATIONS ON THE ROAD AHEAD

by

I. Prakash Sharma
Staff Economist
Economic and Trade Policy Division (CPE)
Policy Staff

(October 1993)

Comments or enquiries on this paper should be addressed to the Policy Staff (CPB), External Affairs and International Trade Canada, 125 Sussex Drive, Ottawa, Ontario, K1A 0G2 (Tel.: (613) 944-0388 or (613) 944-0637; Fax: 944-0687). ISSN 1188-5041. Copies may also be obtained by faxing the Department's InfoExport Centre (BPTE) at (613) 996-9709, quoting code SP30A.

Canada

POLICY STAFF PAPERS/DOCUMENTS DU GROUPE DES POLITIQUES

Recent Papers on Economic and Trade Policy Issues/Récents documents sur des questions économiques et de politique commerciale:

A) **TRADE POLICY SERIES**

1. Globalization and Public Policy in Canada: In Search of a Paradigm, by Keith H. Christie. 93/1 (January 1993) *

2. Trade and the Environment: Dialogue of the Deaf or Scope for Cooperation?, by Michael Hart and Sushma Gera. 92/11 (June 1992)

3. Globalization: The Impact on the Trade and Investment Dynamic, by Dennis Seebach. 93/7 (June 1993) *

4. Merger Control Under Trade Liberalization: Convergence or Cooperation? by Nicolas Dimic. 93/09 (August 1993) *

5. Technology Consortia: A Prisoner's Dilemma? by Rhoda Caldwell. 93/10 (August 1993) *

6. Optimal Patent Term and Trade: Some Considerations on the Road Ahead by I. Prakash Sharma. 93/11 (October 1993) *

7. Competition Policy Convergence: The Case of Export Cartels, by William Ehrlich. (forthcoming)

8. Competition Policy Convergence: Abuse of Dominant Position, by Nicolas Dimic. (forthcoming)

9. The Emergence of "Stateless" Corporations: Implications for Trade, Investment and the Canadian Economy, by Julie Fujimura. (forthcoming)

10. New Jerusalem Revisited: The Impact of Globalization on Canadian Labour Policy, by Rob Stranks. (forthcoming)

11. Financial Sector Deregulation: International Capital Markets and the Canadian Institutional Response, by James McCormack. (forthcoming)

Optimal Patent Term and Trade: Some Considerations on the Road Ahead

EXECUTIVE SUMMARY

The choice of an appropriate patent term can affect positively the economic well-being of Canadians by stimulating research and development (R&D), investment and jobs in high value-added industries. Recently there has been a growing international consensus, led by the United States and others, in support of a 20 year patent term. This is reflected in the 1990 MTN draft final document (the so-called Dunkel text) and NAFTA. The international standard has been set. Nonetheless, in light of escalating R&D costs, there are some suggestions that a longer patent term may be needed to amortize development costs over a longer period. How should policy makers in Canada address this issue if it is eventually raised? This Paper marshals a number of relevant considerations.

What is the optimal patent term? Do some industries require even a longer term than that now provided? The aim of this Paper is to: (a) summarize the conclusions of economic theory on the determination of the optimal patent term; (b) contrast these theoretical conclusions against the recent experience in the pharmaceutical industry; (c) discuss the trade policy implications of the patent term; and (d) address issues of patent policy, besides the patent term, that are likely to be important in Canada's trade with its partners.

The patent system is premised on the reasoning that private markets do not permit innovators to make sufficient profit to recoup their investment. The purpose of patent protection is: (a) to encourage investment in R&D; and (b) to spread the resulting new knowledge throughout the economy. In setting the patent term, authorities have to make a trade-off between: (a) the social cost, in the form of higher prices over the short to medium term, of conferring monopoly rights on the inventor for the duration of the patent life; and (b) the social benefits in the form of increased productivity created by a strong commitment to innovate by business, and of lower prices of new goods and processes after the patent has expired. The criteria for a patent term decision must reflect two features: (a) the lure of monopoly profit must stimulate socially optimal investment in R&D to the level where benefits exceed the costs; and (b) investors in the innovation business must be assured that competitive imitation will be held in check sufficiently long such that monopoly profits exceed R&D outlays.

The determination of optimal patent term involves weighing the benefits against the costs to the economy of extending or shortening the patent term. The longer the patent term, the higher are profits from innovations for potential investors in R&D, and the greater the level of on-going innovation, but the longer society has to wait for lower price benefits from innovations. Furthermore, the higher the R&D level induced by a longer patent term, the greater the production of new goods and processes, and/or the larger the cost reduction in producing them. However, on account of diminishing returns to the innovative activity, each additional year of patent term extension brings about less and less incremental cost saving. It will be economically efficient to cut off patent protection the year the value of the cost saving achieved by additional R&D, due to a longer patent term, equals or falls below the value of benefits of lower consumer prices from the innovation. Going beyond this point, too many resources will be used up in the innovative industry; below this point, too few resources will be allocated to innovations in the economy.

However, there is evidence that, besides patents, there are a number of other factors that are significant in influencing R&D. For example, innovations vary depending on the nature of the research activity, and the degree of competition among inventors and in the product market. Therefore, patents affect R&D activity in different industries and countries in different ways. For instance, if the patent term is increased from 20 to 21 years, the pharmaceutical industry may well benefit (from which further R&D should be expected to flow), whereas it makes no difference to profits in the computer software industry given that the commercial life of new programs is generally considerably shorter than the legal life of the patent. Consequently, a major conclusion of this Paper is that *a different patent term for each industry would be optimal.* The available evidence, on the one hand, confirms that innovations vary across firms and industries. But, on the other hand, it suggests that patents are not central to R&D investment decisions in most industries. Nevertheless, patents and patent term do matter in the pharmaceutical and chemical industries.

One influential economic model argues that optimal patent term in a trading economy crucially depends on the ownership of the innovator, and on its share (60% or more) of the international market in the innovative product. In practice, the market size can be safely disregarded as no country has such a large share of the international market. According to this model, if the innovation is foreign-owned, to a large extent the benefits of a patent taken out in Canada would accrue to foreigners. Therefore, this model concludes surprisingly, economies in general, and small ones in particular, are better off with no or a short patent term (under 6 months). If the innovation, in contrast, is domestically owned, then all the benefits accrue to the domestic society and this model finds a long-lived patent life to be optimal. In sum, this Paper finds that economic theory and empirical studies suggest that a patent term shorter than the present multilateral norm of 20 years will be efficient in most, but not all instances.

On the other hand, this Paper argues that the optimal term prediction of this economic model (i.e., less than six months) is faulty in practice. One major shortcoming of such modelling is that it ignores an essential feature: new knowledge and innovations confer considerable beneficial spillovers on other industries. Increased R&D in one industry in Canada, whether by foreign or domestic investors or through the transfer of foreign technology, and even in industries where only a 4-5 year term may be optimal, will nonetheless benefit firms and workers in many other industries. Clearly, in such a scenario a case for a longer patent term can be made.

This Paper also argues that the scope of patent protection is an important trade policy issue and is likely to take on increasing importance in future trade negotiations. The scope of a patent means patent coverage—the width or breadth. Because patent coverage is open to interpretation, it has the potential of being abused by some countries either to attract R&D investment or to encourage imitation. It is one of the major recommendations of this paper that *trade policy analysis and negotiations should take into consideration the scope of patents*, i.e., the product coverage embedded in each patent grant. In addition, if the patent scope is imprecisely defined, chances are that the patentee will have to incur high money and time costs related to litigation to enforce the patent. This burden could be particularly onerous for small and medium sized enterprises. This Paper suggests that cost minimizing dispute resolution mechanisms or cooperative institutional arrangements be more fully explored. Moreover, for industries where regulatory approval of a patent grant is required, policy makers should first explore whether the regulatory process might be speeded up, thereby increasing the effective commercial life of a given patent, before considering any extension of the legal patent term.

In an integrated world characterized by harmonized patent terms, if one advanced but only moderately successful innovator country, such as Canada, implements a nil or minimal patent term as some economic models suggest, it would be acting in a manner inconsistent with its international obligations and could become subject to retaliation from its major trading partners. Moreover, Canada's failure to follow the international norm in this area would weaken our case that Canada should be viewed as a preferred site for foreign and domestic investments. Although patents are not central to innovation investment decisions in most industries, it would not be a favourable trade-off for Canada to opt for international pariah status among advanced countries. This would send the wrong signals to potential investors in Canada and lead us to forgo technology inflows in the sectors where patent protection is vital.

In conclusion, this Paper argues that as long as our trading partners honour the 20 year norm, it is not in Canada's interest to deviate from the international standard. Deviations from that norm run the risk of being exploited by individual countries and would complicate the multilateral trade environment, unless a consensus could be carefully constructed in advance on the merits of variable patent terms depending on the industry concerned, including both the issues of patent length and scope. Therefore, from the trade policy perspective, this paper concludes that: (a) *the patent term in Canada has to be in line with those of its major trading partners;* (b) *Canada should not seek any general extension of the patent term from its current level;* and (c) *any future extension of the patent term should be limited to those industries where the economics of R&D clearly call for such a change.* In this regard, further cost-benefit work across industries and countries is required.

SOMMAIRE

Le choix d'une durée appropriée pour un brevet peut affecter favorablement le bien-être économique des Canadiens en stimulant la recherche-développement (R-D), l'investissement et la création d'emplois dans les industries à forte valeur ajoutée. La communauté des nations, notamment sous le leadership des États-Unis, s'est récemment rapprochée d'un consensus sur une durée de 20 ans pour les brevets. Cette position se reflète dans le projet de document final des NCM de 1990 (le texte Dunkel) et dans l'ALENA. La norme internationale a été établie. Étant donné toutefois l'escalade des coûts de la R-D, certains suggèrent qu'une prolongation de la durée des brevets pourrait être nécessaire pour répartir les coûts de mise au point sur une période plus longue. Comment les décisionnaires canadiens devraient-ils traiter cette question lorsqu'elle sera soulevée? Ce document présente à ce propos un certain nombre de considérations pertinentes.

Quelle est la durée optimale d'un brevet? Certaines industries ont-elles besoin d'une durée plus longue que celle actuellement accordée? Le présent document vise : a) à résumer les conclusions de la théorie économique concernant la détermination de la durée optimale du brevet, b) à comparer ces conclusions théoriques à l'expérience récente de l'industrie pharmaceutique, c) à discuter des incidences des politiques commerciales sur la durée du brevet, et d) à examiner les questions touchant la politique des brevets, outre celle de la durée, qui revêtront vraisemblablement de l'importance pour le commerce du Canada avec ses partenaires.

Le régime des brevets se fonde sur le raisonnement voulant que les marchés privés ne permettent pas aux innovateurs de faire suffisamment de bénéfices pour récupérer leur mise de fonds. La protection conférée par le brevet a pour but a) d'encourager l'investissement dans la R-D, et b) de diffuser les nouvelles connaissances résultantes dans l'ensemble de l'économie. Lorsqu'elles établissant la durée du brevet, les autorités doivent trouver un équilibre entre a) le coût social (prix plus élevés sur le court à moyen terme) de l'octroi de droits monopolistiques à l'inventeur pour la durée du brevet, et b) les avantages sociaux (gain de productivité généré par un solide engagement envers l'innovation et réduction des prix des nouveaux produits et procédés après l'expiration du brevet). Les critères à appliquer à la prise de décisions sur la durée du brevet doivent refléter les deux éléments suivants : a) l'appât du profit monopolistique doit stimuler un investissement socialement optimal dans la R-D jusqu'au niveau où les avantages excèdent les coûts; et b) ceux qui investissent dans les activités innovatrices doivent avoir l'assurance que l'imitation par les concurrents sera empêchée assez longtemps pour que les profits monopolistiques dépassent les dépenses de R-D.

La détermination de la durée optimale du brevet suppose l'équilibrage des avantages et des coûts économiques liés à la prolongation ou au raccourcissement de la durée du brevet. La prolongation de la durée du brevet accroît les profits que les investisseurs pourront tirer de la R-D novatrice, relève le niveau des activités d'innovation mises en oeuvre, mais oblige la société à attendre plus longtemps pour bénéficier d'une réduction des prix des nouveaux produits. De plus, l'accroissement du niveau de R-D généré par la prolongation de la durée du brevet stimule la production de nouveaux produits et procédés et réduit les coûts de production. Toutefois, la décroissance des rendements obtenus par l'activité novatrice fait que chaque année additionnelle de protection conférée par le brevet entraîne une baisse de plus en plus marquée des épargnes au niveau des coûts de production. Il sera économiquement efficient de mettre fin à la protection conférée par le brevet lorsque la valeur des épargnes générées par la R-D additionnelle en raison de la prolongation de la durée du brevet devient égale ou inférieure à la valeur des avantages de l'innovation en termes de réduction des prix à la consommation. Au-delà de ce point, trop de ressources seront utilisées par l'industrie innovatrice; en deçà de ce point, trop peu de ressources seront allouées à l'innovation dans l'économie.

Mais il semble que le brevet ne soit pas le seul facteur exerçant une forte influence sur la R-D. L'innovation est aussi influencée par la nature de l'activité de recherche et par le degré de concurrence entre les inventeurs et sur le marché du produit. Les brevets affectent donc différemment l'activité de R-D selon l'industrie et le pays en cause. Par exemple, si la durée du brevet était portée de 20 à 21 ans, l'industrie pharmaceutique pourrait bien en profiter (ce qui devrait entraîner un accroissement de la R-D), alors que l'industrie du logiciel d'ordinateur n'y verrait aucun effet sur ses bénéfices étant donné que la période de commercialisation des nouveaux programmes est généralement bien plus courte que la durée d'application du brevet. Par conséquent, ce document en arrive à la grande conclusion qu'*une durée de brevet différente pour chaque industrie serait optimale.* Les données disponibles confirment que les innovations varient selon les firmes et les industries. Mais elles suggèrent aussi que les brevets ne sont pas essentiels aux décisions d'investissements en matière de R-D prises dans la plupart des industries. Il reste toutefois que les questions du brevet et de sa durée ont une réelle importance pour les industries des produits pharmaceutiques et chimiques.

Selon un modèle économique souvent utilisé, la durée optimale du brevet dans une économie commerçante dépend essentiellement de la structure de propriété de l'innovateur, et de sa part (60% ou plus) du marché international pour le produit novateur. Dans la pratique, la taille du marché peut être ignorée sans problème puisqu'aucun pays n'a une part suffisamment large du marché international. Selon ce modèle, si l'innovation est détenue par des intérêts étrangers, les avantages d'un brevet pris au Canada reviendraient largement à des étrangers. Ce modèle en arrive à l'étonnante conclusion que les économies en général, et les petites économies en particulier, sont avantagées par des brevets sans durée ou de courte durée (moins de 6 mois). Mais si l'innovation est détenue par des intérêts locaux, tous les avantages en reviennent à la société locale, et ce modèle juge optimal l'octroi de brevets de longue durée. En résumé, ce document conclut que, selon la théorie économique et les études empiriques, une durée de brevet plus courte que la norme multilatérale de 20 ans actuellement appliquée sera presque toujours rentable.

Le document soutient par ailleurs que la durée optimale prédite par ce modèle économique (c.-à-d. moins de six mois) ne résiste pas à la pratique. Ce type de modèle, et c'est là l'une de ses grandes lacunes, ignore le fait pourtant essentiel que les nouvelles connaissances et les innovations ont d'importantes retombées positives sur d'autres industries. L'accroissement de la R-D dans une industrie du Canada, que cette activité soit générée par des investisseurs étrangers ou locaux ou soit menée au moyen de transferts de technologie étrangère, et même dans des industries où une durée de protection de 4-5 ans seulement pourrait être optimale avantagera quand même les entreprises et les travailleurs de plusieurs autres industries. Il est clair qu'un tel scénario pourrait justifier une durée de brevet plus longue.

Ce document soutient aussi que la portée de la protection conférée par le brevet est une grande question de politique commerciale qui prendra probablement de plus en plus d'importance dans les futures négociations commerciales. Par portée du brevet, on entend son champ d'application -- soit son ampleur ou son étendue. Comme le champ d'application du brevet est sujet à interprétation, il se peut que certains pays en abusent pour attirer des investissements dans la R-D ou pour encourager l'imitation. L'une des grandes recommandations de ce document est que *l'analyse de la politique commerciale et les négociations commerciales devraient tenir compte de la portée des brevets*, soit des produits visés par chaque brevet délivré. De plus, si la portée est mal définie, il y a des chances que le titulaire du brevet doive engager passablement d'argent et de temps à défendre son brevet devant les tribunaux. Ce fardeau pourrait être particulièrement onéreux pour les petites et moyennes entreprises. Ce document propose d'explorer plus en détail des mécanismes de règlement des différends ou des arrangements institutionnels de coopération tendant à réduire ces coûts au minimum. De plus, dans les industries où l'approbation réglementaire est requise pour la délivrance d'un brevet, les décisionnaires devraient se demander si le processus réglementaire pourrait être accéléré pour prolonger la période de commercialisation effective d'un brevet avant d'envisager toute prolongation de la protection juridique conférée par le brevet.

Dans un monde intégré où la durée des brevets est harmonisée, un pays avancé mais pas particulièrement innovateur -- comme le Canada -- qui appliquerait une durée de brevet nulle ou minimale, conformément à la théorie économique, contreviendrait à ses obligations internationales et pourrait faire l'objet de mesures de rétorsion de la part de ses grands partenaires commerciaux. De plus, son refus d'appliquer la norme internationale dans ce domaine ferait que le Canada aurait plus de difficulté à faire valoir qu'il peut attirer les investissements étrangers autant que locaux. Bien que les brevets ne soient pas essentiels aux décisions d'investissements novateurs prises par la plupart des industries, le Canada n'aura pas avantage à devenir le paria des pays avancés. Cela enverrait de mauvais signaux à ceux qui songent à investir au Canada et nous ferait perdre des apports technologiques dans les secteurs où la protection par brevet est vraiment essentielle.

En conclusion, ce document soutient que, aussi longtemps que nos partenaires commerciaux honorent la norme de 20 ans, le Canada n'a pas intérêt à s'éloigner de la norme internationale. Les déviations par rapport à cette norme pourraient être exploitées par certains pays et compliqueraient l'environnement commercial multilatéral, à moins qu'on ne puisse établir à l'avance un consensus soigneusement équilibré sur les avantages de durées variables pour les brevets selon l'industrie en cause, et que l'on puisse notamment s'entendre sur la durée et la portée des brevets. Sous l'angle de la politique commerciale, ce document en arrive donc aux conclusions suivantes : a) *la durée du brevet au Canada doit être alignée sur celle appliquée par nos principaux partenaires commerciaux;* b) *le Canada ne devrait pas rechercher une prolongation générale de la durée actuellement appliquée au brevet;* et c) *toute future prolongation de la durée du brevet devrait être limitée aux industries pour lesquelles l'économique de la R-D commande clairement un tel changement.* À cet égard, il faut explorer plus en détail l'analyse coûts-avantages aux niveaux des industries et des pays.

I

AN INTRODUCTION

Patents are used to pursue the twin goals of encouraging production and the diffusion of innovations in the economy. A balanced patent law is a crucial instrument for encouraging the development of high-technology industries, such as biotechnology, semiconductors and computer software. The issue of patent term is becoming increasingly important in international trade negotiations.[1] The perceived failure to provide an "adequate" level of patent protection has led technology rich countries to complain of "piracy", because their firms have lost proprietary revenues. Consequently, since the 1980s the issue of patent protection has become a high profile trade policy issue.

This paper discusses what a socially optimal patent term might be in an economy engaged in international trade. In this regard, there emerge several policy, theoretical and methodological issues: (a) What is the optimal patent term? (b) Is it necessary to analyze patent policy from a trade policy perspective rather than in a non-trading domestic economy? (c) How useful is patent policy, and patent term in particular, in achieving its goals? (d) Are there other means, related to or independent of patent policy, by which those goals could be pursued?

This paper argues that trade issues in patent policy development are sufficiently important to warrant an extension of the non-trading economy model widely used in the economics literature. For example, an interesting policy question in a multilateral world characterized by harmonized intellectual property (IP) rights is: What is the effect of a free trade area on economic welfare in member countries characterized by innovation industries of different scope and scale? Patent analysis clearly requires an international trade perspective.

Innovations are achieved through investment in the production of new knowledge. If an innovation is made public knowledge, the innovator can hardly make a monetary profit. Even product-specific innovations that are kept as proprietary knowledge can be "reverse engineered" by imitators. Such imitation robs the innovator of monetary rewards and incentives to invest in the production of knowledge.

[1] Presently, in Canada the patent term is 20 years from the date of filing a patent application with the Patent Office. A patent is granted after the authorities have verified the innovator's claim that the invention is new, useful and a non-obvious production process, machine, manufacture, composition of matter, improved or new good.

The Patent System

The objective of the patent grant is to encourage firms to invest in innovations and to facilitate the spread of knowledge for stimulating further creativity in the economy. A patent confers the right on the innovator to exclude all others from making, selling, or using the subject matter of a valid patent. The patentee firm can either "work" the patent itself or sell licenses for a royalty and let other businesses commercialize the invention. Since the patentee is the only legal supplier of the innovative product or process, we have a situation of a monopoly. A monopolist firm sets the price higher than the unit production cost, and thereby makes super-normal profits or "rents". Over the life of the patent, the patent-holder is legally entitled to these monopoly rents. Consumers of the patented products pay the higher prices. A patent system viewed in this way, shifts some of the *consumers' surplus* to the patentee as rents. As in the case of a monopoly, appropriation of patent rents entails economic inefficiencies.

Why should the society let the innovator appropriate the rents? In its profitability calculus, the innovator takes into account only private revenues and costs. Social benefit in the economy is the sum of net benefits to *all* businesses and consumers. Innovations have considerable beneficial spillovers or externalities for other industries and consumers. Taking these additional benefits into account makes the social benefit[2] of innovations greater than the private benefit the innovator calculates for itself. To the extent the patentees can capture the monopoly profits, innovations should increase and a socially efficient level of resources will be employed in innovative industries. Thus, it makes sense to let the innovators appropriate monopoly rents up to a certain point. Moreover, when innovative firms make profits, some households still benefit as shareholders.

The "piracy" of new knowledge results in the diffusion of innovations when imitators come out with new varieties at lower prices than charged by the patentee. But if such competition is introduced too soon, either through illegal copying or by setting a patent term of short duration, the innovator may not make profits that offset the costs of innovation. Patent infringement takes the incentives away from innovators to invest in the production of knowledge. On the one hand, from society's viewpoint, the diffusion of new technology and knowledge is beneficial. But, on the other hand, if the diffusion of the patented knowledge transmits disincentives to innovators, society is saddled with too low a level of innovation compared to what would be optimal. Consequently, the life of a patent should be long enough to enable the investors to make a profit on their innovations, which in turn will encourage further innovations in the economy and bring about an efficient allocation of resources.

---

[2] That is, economy-wide benefits.

The present patent regime is premised on the argument that perfectly competitive markets fail to reward inventors sufficiently and that society consequently suffers a sub-optimal level of R&D if a patent regime is not in place. The level of R&D can be raised by assuring investors in new knowledge-generating industries super-normal profits long enough to recoup their investment. For such a profitable market, the price must exceed the incremental cost of the product. Thus, in industries where the private market mechanism does not result in profits that can offset investment in innovation, the patent system is clearly indispensable. After all, if only a few innovations get produced, then there is not much new knowledge that can go around and spread to other industries, nor will consumers receive the benefits of new goods and eventually lower prices. It is also clear that an efficient patent system should not let a patent go on too long and thus deprive the patentee's competitors and consumers full benefits of new technology and goods. Thus, the determination of optimal patent life requires balancing the goal of stimulating investment in innovations against the goal of spreading new knowledge. Let me illustrate the nature of the trade-off involved in the determination of the optimal patent term by using a simple numerical example.

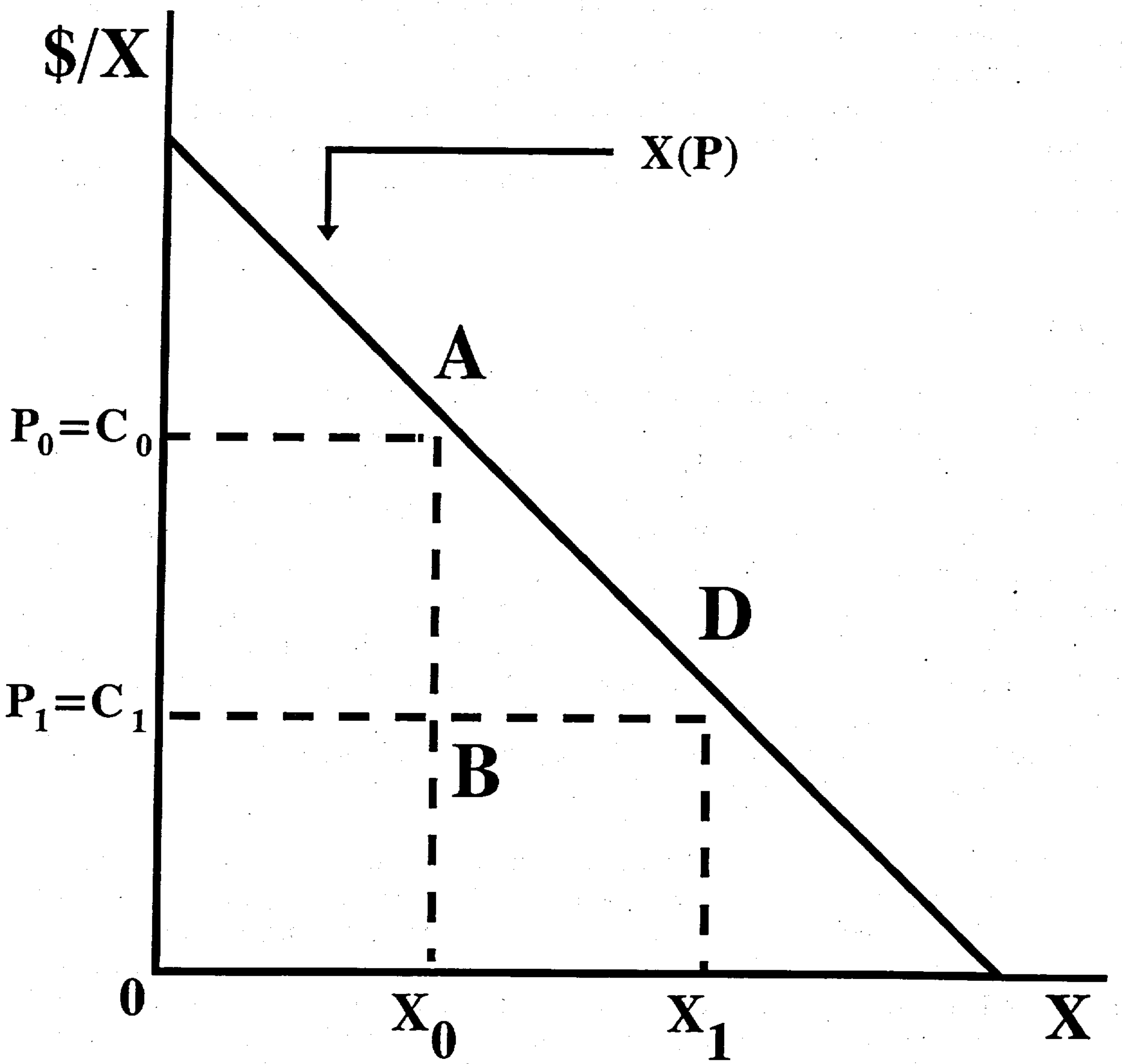
- **Optimal Patent Term:** *An Example*

To illustrate the effect of a patent system on welfare, consider Figure 1. The industry demand curve is X(P). The unit cost, $0C_0$, say equal to \$100, is constant. Price without patents is $0P_0$, which equals the incremental cost and unit cost, such that output is $0X_0$, or say equal to 10 units. After incurring R&D resource costs, an innovation is produced and a patent of life T, say 20 years, is obtained which lowers costs to OC^1, say to \$80. The price remains at the pre-innovation level at \$100, so consumers do not benefit from the innovation for the life of the patent. Instead, there is a gain of the area P_0P_1AB or \$200 per year of *rents* for T years to the patentee. The innovative firm can produce the output of 10 units and appropriate the monopoly rent or it can license the patent to existing producers, charging a royalty of \$200 per year. After T years the patent expires and price falls to $0P_1$ or \$80, and output expands to $0X_1$, say equal to 12 units, so there are now gains in the surplus to consumers of the area P_0P_1AD.

First, it is clear that the level of welfare changes as T, the patent life, changes. To determine the optimal patent life, we need to take into consideration: (a) the present value of rents captured by the patentee; plus (b) the present value of the total consumers' surplus from the expiry of the patent to the time the product is no longer marketed; minus (c) the innovator's R&D costs. Suppose that a patent term extension from 20 years to 21 years is being considered. How does this affect a potential patentee, who is trying to figure out what R&D investment to make? One consequence of the extension will be that the patentee will legally get to appropriate the rents of P_0P_1AB = \$200 for one additional year.

Figure 1

Price and Output Consequences of a Cost Reducing Invention



Clearly, the benefits to consumers will be delayed by that one year. However, it is not simply a matter of transferring $200 from the consumers to the patentee. Consumers and society also miss out each year on the area ABD or $20. The total consumers' benefit that is foregone each year is $220. Recall that as the patent term is increased from year zero toward 20 years, the prospect of capturing rents for a longer period induces innovators to incur additional R&D expenditures. As R&D undertaken rises, the resulting innovations will initially achieve larger and larger overall cost reductions. Eventually, however, the new incremental cost reductions will get smaller and smaller as diminishing returns to the innovative activity set in. Though the amount of the cost reduction rises overall in each year as the patent term is extended, consumers and society must wait longer and longer to appropriate the welfare triangle ABD. Each additional year's wait brings about less and less incremental cost reduction. Moreover, because rents from later years are discounted more heavily than those in early years[3], beyond a certain number of years the increase in the gain to the patent holder from a longer patent term is relatively modest. Sooner or later, these diminishing-return effects overpower society's interest in stimulating additional cost reduction by extending the patent life.

Intuitively,[4] it will be efficient to cut off patent protection the year the value of cost reductions (in today's dollars) achieved by additional R&D, due to a longer patent term, falls below the value (in today's dollars) of the welfare loss of triangle ABD or $20. Optimal patent duration is reached when incremental costs are offset by incremental benefits of innovations. Returning to our example, if the patent term extension by one year stimulates innovations that bring about a cost reduction of $19, whereas the welfare loss is $20, then the optimal patent term is 20 years and extending it to 21 years will be inefficient. Going beyond this point, too many resources will be used up in the innovative industry; below this point too few resources are being allocated to innovations in the economy.

The example also suggests that if the cost-benefit calculus is done for each industry, we will come up with different optimal patent terms in the economy. Depending on the nature of innovations, the size of investment required to produce them will vary across industries and so would the optimal patent term that would enable companies to capture profits to off-set the R&D costs. In some industries, innovations are "easy"; they can be

[3] This is so because most of the R&D expenditures are in current dollars, whereas the rents accrue over the life of the patent. Discounting converts future period dollar rents into present value dollars. The rent in each year is divided by one plus the interest rate or the discount rate. For instance, $200 you may get next year amount to $190.50 in today's dollars if the interest rate is 5 percent. A dollar today is worth more than the one dollar 20 years hence.

[4] The formal analysis and determination of the optimal patent term is in Annex A.

achieved with small outlays. In others, innovations are "hard"; large investments upfront are required. In some industries, innovations are riskier than in others. These considerations, in theory at least, would call for an optimal patent system that tailors the patent term to suit the characteristics of each industry in the economy. In practice, authorities have generally opted for a common patent term in the economy. Nevertheless, taking the current 20 year term as an example, in a uniform patent term regime the patent system as applied in a given industry may or may not be economically efficient in an economy-wide sense. In industries where innovations are "easy" or the return on innovations is high, the commercial usefulness of patents turns out to be much shorter than the official 20 year life. The computer software industry is one case, where the effective life of innovations in the market place is not much longer than 6 to 8 years.

Empirical studies confirm that the propensity to engage in R&D as well as innovation performance vary across firms and across industries in the economy.[5] Consequently, there are very large differences, both among industries and within them, in the effectiveness of patents. Studies also show that patents were considered essential to developing and marketing inventions only in the chemical industry generally, and in the pharmaceutical industry in particular.[6]

Why are patents not deemed necessary for innovations by most industries? One explanation is that it may be true that profits in a perfectly competitive market are so small that they do not offset the R&D costs of innovations. Nevertheless, patent or no patent, most of <u>the innovative products and processes are traded in imperfectly competitive markets.</u>[7] Consequently, innovators may find super-normal profits earned in imperfectly competitive markets as an "adequate" return on their investment. From this view, two sorts of policy arguments can be drawn.

First, in imperfectly competitive markets, firms make above normal profits as it is, without any government grant of monopoly patent rights. Should the patent grant still top up those profits? True, R&D activity is risky and requires large investment. But much of

[5] Discussed in Giovanni Dosi, "Sources, Procedures, and Microeconomic Effects of Innovation", *Journal of Economic Literature*, 26, September 1988: 1120-71.

[6] Edwin Mansfield, "Patents and Innovation: An Empirical Study," *Management Science*, vol. 32, February 1986: 173-81. R.C. Levin, A.K. Klevorick, R.R. Nelson, and S.G. Winter, "Appropriating the Returns from Industrial Research and Development", *Brookings Paper on Economic Activity*, 3:1987: 783-820.

[7] In imperfectly competitive markets, there are only a few firms, each with some market power to set the price of its product. In perfect competition, there are numerous firms, each unable to set the price of its product; the price is determined in the competitive market itself.

it is also the product of deliberate economic calculations of profit maximizing firms. In an integrated world, domestic firms develop innovative products and processes with not only the domestic market on their mind, but with imperfectly competitive world markets in view as well. And imperfectly competitive world markets may provide even bigger profits over a longer term to innovative firms. In imperfectly competitive world markets, there are forces that motivate firms to do R&D even without patent protection. Innovations in such an industry are generated by the interplay of forces within the market itself. Therefore, in this view, the case for patent protection is hard to make.

However, the opposite case can also be made. Consider the first argument again. Firms are able to sustain comparative advantage in imperfectly competitive markets largely on account of their investment in innovations. New products or existing products at cheaper prices are a key to comparative advantage in international markets. Firms engage in R&D activities and bring out innovative products continuously. Moreover, when firms are engaged in competition and jostling to sustain "top dog" position in international markets on the basis of innovative products and processes, they want to be assured that their innovations are not imitated for the longest possible time. These firms recognize that due to intense innovative competition from rivals, their products cannot take the benefit of the full legal patent life. Nonetheless, these firms patent their innovations to establish their presence and to be ahead in the market for the next round of competition. In this view, patents serve the purpose of establishing property rights with some rents to go with them. Private markets do provide super-normal profits on large and risky innovations, but to appropriate such rents even imperfectly competitive firms have to fall back on the patent system. And if private markets do <u>not</u> provide such a return in specific cases, firms develop alternative mechanisms and institutions to facilitate making a profit. Joint research ventures or other forms of cooperative research are institutions that emerge in response to such market situations. <u>The institution of patents is the bedrock of such an innovative economy</u>; yet a long patent term is not central to the incentives to investment in most innovations.

The argument that imperfectly competitive international markets generate currents that propel firms to innovate on their own can be further strengthened by recognizing that R&D activity in the economy is also determined by other factors, such as tax policy, the degree of market competition, demand growth and corporate restructuring. Empirical studies show that, along with patents, these factors have significant influence on R&D activity.

Even in the new growth theory outlined above, taking into account beneficial spillovers inherent in innovations and the profits made in imperfectly competitive international markets, patents, though essential, matter less than the diffusion of innovations. In this view, diffusion or imitation of innovations may be much more important than innovations.[8] Many countries may be prone to over-emphasize R&D. For many purposes, the important thing is innovation, not R&D, which by itself has little or no value. Many innovations are not based on any formal, sophisticated R&D. It is much more important for an economy to exploit a new technology successfully than to be the first to introduce it. And for speedier diffusion, a shorter patent term is more likely to be efficient than a longer one.

Economic theory argues that optimal patent term in a trading economy crucially depends on two factors: (a) the ownership of the innovator, and (b) whether or not its firms have a large share (60 percent or more) of the international market in the innovative product. If the innovation is foreign-owned, to a large extent the benefits of a patent taken out in Canada would accrue to foreigners. Moreover, in practice, no country has such a large share of the international market and thus this factor can, in practice, be safely disregarded. Therefore, the theory concludes surprisingly, economies in general, and small ones in particular, are better off with no or a short patent term (under six months). If the innovation, in contrast, is domestically owned, then all the benefits accrue to the domestic society and economic theory finds a long-lived patent life to be optimal.

Nevertheless, this paper argues that this optimal term prediction of economic theory is faulty in practice. We undertake below a rough check against recent evidence in the pharmaceutical industry in Canada. There are two major shortcomings in such economic models. First, new knowledge and innovation in a dynamic economy have considerable beneficial spillovers on other industries. Second, in an integrated world characterized by harmonized patent terms, if one advanced but moderate innovator country, such as Canada, implements the apparent first-best policy of a nil or minimal patent term for many industries as some theory suggests, it would be acting in a manner inconsistent with its international obligations and could become subject to retaliation from its major trading partners. Moreover, Canada's failure to follow the international norm in this area would weaken our case that Canada should be viewed as a preferred site for foreign and domestic investments. As discussed above, although patents are not central to innovation investment decisions in most industries, it would not be a favourable trade-off for Canada to opt for international pariah status amidst advanced countries. This would worsen the investment climate in Canada and lead us to forgo technology inflows in those sectors for which patent protection <u>is</u> vital.

[8] Edwin Mansfield, "Technological Change and the International Diffusion of Technology: A Survey of Findings". In *Technological Change in Canadian Industry*, volume 3 of the research studies prepared for the Royal Commission on the Economic Union and Development Prospects for Canada. Toronto: University of Toronto Press, 1985.

- **Scope of Patent**

This Paper finds that the scope of patent protection is also an important trade policy issue and is likely to take on increasing importance in future trade negotiations. The scope of a patent means patent coverage, i.e., width or breadth. Because patent coverage is open to interpretation, it has the potential of being abused by some countries either to attract R&D investment or to encourage imitation. It is one of the major recommendation of this Paper that trade policy analysis and negotiations should take into consideration the scope of patents.

- **Preliminary Conclusions**

This Paper finds that economic theory and empirical studies suggest that a patent term shorter than the present multilateral norm of 20 years will be efficient in most instances. Exceptions include industries, such as chemicals (including the pharmaceutical industry), where a case for a longer patent term is possible. Nonetheless, as long as our trading partners honour the 20 year standard, it is not in Canada's interest to deviate from the international norm. Deviations from that norm run the risk of being exploited by other countries to attract investment and innovative activity and would complicate the multilateral trade environment unless a consensus could be carefully constructed in advance on the merits of variable patent terms depending on the industry concerned, including both the issues of patent length and scope. To arrive at precise numbers for industry-specific patent terms, further cost-benefit work across industries and countries is required.

Finally, innovation activity in Canada does not only nor even primarily respond to intellectual property (IP) rights. Our policies concerning economic growth and investment (especially foreign direct investment), competition, taxation and the development of entrepreneurship are more important. These policies have more effect on a country's rate of innovation than its policies concerning industrial IP rights.

The rest of this Paper is set out as follows. Section II begins an explanation of the basic logic of patent protection. In sub-section II.1, we discuss the Nordhaus model[9], which provides the most illuminating optic for exploring optimal patent term determination. It is followed, in sub-section II.2, by a review of the literature related to the optimal patent term in a non-trading economy framework. In sub-section II.3, the framework is extended to a trading economy and optimal patent term conclusions are discussed. In order to check

[9] William D. Nordhaus, *Invention, Growth and Welfare*, Cambridge, Mass.: The MIT Press, 1969, chapter 5. F.M. Scherer, "Norhaus' Theory of Optimal Patent Life: A Geometric Reinterpretation", *American Economic Review*, 62, June 1972: 422-427. W.D. Nordhaus, "The Optimum Life of a Patent: Reply", *American Economic Review*, 62, June 1972: 428-431.

the theoretical predictions, in section III we turn to the pharmaceutical industry in Canada. We find that the evidence is at odds with the theory. The modification of theory is needed. We include a brief review of Canadian patent policy. Next, the policy implications of the patent term and policy debate are taken up. In section IV, a brief description of new growth theory is given. In these models, R&D activity by imperfectly competitive firms in world markets brings about growth.[10] The optimal patent term issues are addressed in the framework of imperfectly competitive product markets and where R&D activity is market propelled. This section is concluded by suggesting specific predictions about the optimal patent life in a trading economy. In section V, the analysis turns to the scope of patents and includes a brief discussion of the issue of litigation costs associated with patent protection. Conclusions are found in section VI. In Annex A, the Nordhaus model is formally worked out. In Annex B, there is a discussion of the interaction of R&D activity and other factors, such as tax policy, the degree of market competition, demand growth and corporate restructuring. The discussion of these issues is supported by empirical evidence in each case. Annex C comprises charts illustrating the changes to average effective patent protection afforded to patented medicine in Canada.

[10] Gene M. Grossman and Elhanan Helpman, *Innovation and Growth in the Global Economy*, Cambridge, Mass: MIT Press, 1991.

II

THE THEORY OF THE OPTIMAL PATENT TERM

The purpose of the patent grant is to enable innovators to capture rents from their innovations and to provide an incentive to invest in innovations. An innovation is achieved through an advance in knowledge. An advance in knowledge that results in a *final* good not previously available is called a **product innovation**. A **process innovation** is an improvement in the production process such that the cost of producing existing products is reduced.[11]

One aspect of economic efficiency of perfectly competitive markets is that the profit maximizing firms bring forth a socially optimum level of private investment. But marginal cost pricing[12] of innovations in competitive markets will result in such a small price that private profits will be too low to achieve an efficient level of investment in innovations.

Take a current example in the consumer product field. Before the high-definition television (HDTV) can be marketed to consumers, substantial R&D expenditures have to be incurred upfront. Only a few firms are willing to develop the HDTV by committing such a large sum. To make a profit on the project, the innovating firms will price their product above its marginal cost. These profits will lure competitors to move into the HDTV market. The new entrants could simply "reverse engineer" the HDTV production process without incurring the upfront cost in R&D. As the number of firms marketing HDTV increases, the price will equal marginal cost such that firms make little or no economic profit. Innovators of HDTV will not be able to recoup their large "sunk" investments.

The HDTV example shows that if firms cannot recoup their investments through profits from selling innovative products and processes, they will not undertake R&D in HDTV in the first place. Society will forgo benefits of innovations and will be saddled with too low a level of R&D activity. Thus, the grant of an IP right to the inventor is an appropriate policy in this situation.

The patent offers a temporary right to exclude competitors from marketing the innovation. Inventors can expect that prices will remain above post-invention production and marketing costs long enough such that the discounted present value of the profits will exceed the value of the front-end investment.

[11] Inventions are a result of basic or fundamental research. It is at the point of commercial introduction that the new product or process is described as an innovation.

[12] Marginal cost is the cost of producing an incremental unit.

To the extent imitators can come up with knock-off versions of the patented invention, the exclusivity of the inventor's property rights to appropriate rents is eroded. In industries where exclusivity of a patent grant cannot be enforced, the diffusion of new knowledge takes place, but at the cost of diminished incentives for doing R&D.

Over the period during which a patent permits excludability, consumers of the new product will pay higher prices and competitors will not be able to use new knowledge. That is, over its life a patent limits the short-term price benefits to consumers and the diffusion of new knowledge. Once the patent expires, the benefits of the innovation are transferred from the original innovator to consumers and competitors. After the patent has expired, society enjoys the fuller benefits of the innovation: lower prices, better product quality and variety.

II.1 THEORY OF THE OPTIMAL PATENT TERM IN A NON-TRADING ECONOMY

In the theoretical scenario of a non-trading economy, product and input markets are assumed to be perfectly competitive. Models, however, differ in what they assume about rents that a patentee can be capture. In a competitive innovation industry characterized by a large number of firms competing to be the first to get the patent, the potential rent associated with the patent will be largely dissipated.[13] The amount of rents that can appropriated depends on a number of factors, such as: (a) the nature of competition before the patent grant in the invention industry;[14] (b) whether the patent right provides effective exclusivity in the innovation product or process market; and (c) the size of the innovation.

To begin with, the amount of profits that a patentee can capture depends on the size of the innovation. A *major* innovation, also called a *drastic* innovation, causes the price of the product to fall significantly below the pre-innovation price. Major innovations result in large appropriable rents. The HDTV project is an example of a major innovation.

[13] See, Yoram Barzel, "Patents, Property Rights and Social Welfare: Search for a Restricted Optimum", *Southern Economic Journal*, 43, October 1976: 1045-1055; George J. Stigler, *The Organization of Industry.* Homewood, Ill.: Irwin, 1968; Glenn C. Lourey, "Market Structure and Innovation", *Quarterly Journal of Economics*, 93, 1979: 359-410; and Donald M. McFetridge and M. Rafiquzzman, "The Scope and Duration of the Patent Right and the Nature of Research Rivalry" in John Paplmer (ed.), *Research in Law and Economics: The Economics of Patents and Copyrights*, Volume 8, Greenwich, CT: JAI Press, 1986: 91-129.

[14] The nature of product market competition after the patent has expired will also determine whether the reputation effect that the patentee has been an innovator enables it to make above-normal profits.

However, the appropriable rent is much smaller for a *minor* or *run-of-the-mill* innovation, also called a *nondrastic* innovation, which results in a small price reduction. Note that most of the patented innovations tend to be marginal improvements over existing products and processes. In this Paper, like most of the literature, the focus is on small or "run-of-the-mill" innovations.

The nature of competition in the innovation industry and the degree to which the patent permits market exclusivity, determine how much rent can be appropriated by the patentee. In a process innovation industry, consider two competition structures and two possibilities of exclusivity. First, take a monopolized innovation industry which has a unique innovator with effective patent exclusivity rights. Clearly, the monopolist innovator can capture all the rent that can be appropriated. A longer patent term would increase its incentive to do R&D. Second, suppose that imitators can "invent around" the monopolist innovator's patent. The longer the patent term, the greater the rent and the faster imitators move in and nibble away at an innovative monopolist's profits. From society's point of view, any lengthening of the patent term simply dissipates appropriable rents. Third, consider the case of easy entry in the innovation industry and effective patent exclusivity. The competition in the production of innovations ensures that firms race to patent the innovation. Patent races mean that rivals are duplicating R&D, an activity wasteful from society's point of view. A longer patent term, in this case, will increase the pace of R&D. Innovations will be patented sooner rather than later. This will entail a misallocation of resources in the economy and an erosion of appropriable rents from the patent. Finally, easy entry by innovators and the presence of imitators around the patentee would imply that all the appropriable rents will be competed away. From society's viewpoint, in order to channel an efficient level of resources to the innovation industry, it is necessary that as much appropriable rents as possible are preserved. In the non-trading, perfectly competitive economy model, the longer the patent term or the broader the scope of the patent grant, the greater is the fraction of surplus which can be appropriated by innovators and the greater is the value of innovations which will be forthcoming.

One aim of patent policy is to preserve rents long enough such that innovators find it attractive to invest in R&D and bring it to an efficient level. To reach the socially optimum level of R&D, the private marginal cost incurred by innovators would have to equal the economy-wide (or social) benefits. Therefore, the patent policy must aim to minimize the dissipation of rents. To determine the optimal patent term, we simply find that point in time up to which the level of R&D has not achieved the efficient level from the entire economy's point of view. Such a situation exists when, at the margin, costs imposed by monopoly pricing by the patentee equal or exceed the potential benefits in the entire economy from the diffusion of the patented innovation.

- **The Nordhaus Model**

Nordhaus[15] assumes that once a unique innovator in the competitive innovation industry is granted a patent, the patent confers complete appropriablity of the rents. Nordhaus considers nondrastic process innovations that reduce the cost of producing an existing good. There is a positive relationship between R&D expenditures and the output of innovations, and, consequently, an inverse relationship between R&D expenditures and unit production cost. As the innovative effort increases, the incremental returns to R&D, though positive, begin to diminish. Increased R&D brings about a reduction in the unit cost of production of the good. A social welfare or net surplus function, defined as consumers' surplus plus producers' surplus minus resource cost, is formulated for the purpose of determining the optimal patent term. The welfare function is maximized, subject to the profit maximizing innovator's choice of the level of R&D. Welfare maximization results in a solution that yields the optimal patent term as determined by a number of factors.[16]

There are three important factors in Nordhaus' social welfare maximizing calculus of optimal patent life: (1) the responsiveness of demand to price changes; (2) the "ease" or "difficulty" of achieving cost reducing innovations; and (3) the gains from competitive imitation.

There are three major conclusions from Nordhaus' model. First, the greater the responsiveness of demand to price reductions, the shorter the optimal patent term. As the demand responsiveness increases, the area of the welfare triangle (the area ABD in Figure 1 above) increases, making society less and less willing to postpone its capture. Second, the easier it is to achieve a given cost reduction, the shorter the optimal patent term will be. When big cost reductions are likely, whether the allowed patent term is modest or long, society is less willing to postpone the realization of its net welfare surplus to motivate still more cost reduction than it would be if the cost savings under comparable patent term conditions and research investments were modest. Third, the smaller the cost reduction induced by an increase in patent term which reduces society's welfare gain by deferring competitive imitation, the shorter the optimal patent term. Nordhaus finds that for easy innovations the socially optimal patent term is shorter than 8 years, whereas for difficult innovations even a 20 year patent term is insufficient.

---

[15] William D. Nordhaus, 1969, *op. cit.*

[16] A formal analysis of the Nordhaus model is presented in Annex A.

Thus, the patent term plays two investment-inducing roles. First, an optimal patent policy sees to it that the monopoly rent stimulates R&D investment just sufficient to equate the economy-wide marginal gain from further cost reduction with marginal cost. Second, the patent grant must persuade investors that competitive imitation will be deferred sufficiently long to make discounted rents exceed the R&D investment level. Neither aspect can be ignored in designing an optimal patent policy.

- **Different Industries, Different Optimal Patent Term**

The nature of innovation activity differs across industries. In some industries, large outlays bring forth small innovations, while in others, R&D expenditures need not be that large. Markets for innovations differ as well. In some markets, customers will pay the high monopoly price to buy the latest, whereas in others they may wait until the price falls on the patent's expiry. Optimal patent term is longer for high cost R&D projects and small market size than for small to medium cost innovations that are sold in large markets. Moreover, drastic and risky innovations would generally merit a longer rather than a shorter patent term. Therefore, in theory, a fixed patent term is not optimal, although it may be unavoidable in practice.

II.2. PATENT TERM ISSUES IN ECONOMICS LITERATURE

A. The Patent Carrot: *Useful or Shrivelling Carrot?*

- *Imitation Eats into Patent Rents*

The patent regime is designed to keep imitators out. Patent protection is weak if there are many viable solutions to a technical problem, such that other firms can "invent around" a given patented solution. Nor can a longer patent term be effective in preventing imitation when patent protection turns out to be weak. To be sure, companies often seek to fence in their technological domain by patenting every conceivable variation on a product or process. But individual patents that solidly protect a whole field of product or process technology are rare. Nevertheless, patent protection appears to be relatively important where the coverage is an all-or-nothing affair. For example, to introduce a new drug during the late 1980s in the U.S., Scherer and Ross[17] estimated the R&D and testing costs at between \$50 to \$100 million. Most of these costs were incurred discovering molecules with desirable therapeutic effects in humans and proving through extensive clinical testing that the substances were effective and safe. After that, it typically costs only a few hundred

[17] F.M. Scherer and D. Ross, *Industrial Market Structure and Economic Performance*, Boston, MA: Houghton Mifflin, 1990.

thousand dollars for a competent biochemist to develop production methods. Thus, if there is no patent regime, imitators can free ride on most of the innovator's investment.

Patents in general do affect the cost of duplication and imitation. Levin and colleagues[18] learned in a broad-ranging survey of corporate R&D decisions that patent protection increased imitation costs by 40 percentage points for pharmaceutical products (relative to a scale on which equally costly imitation is 100), by 25 points for typical chemical products; by 7 to 15 points for semiconductor, communications equipment, and computer products; and by an average of 17 percentage points for machine tools, pumps, and compressors. Although "reverse engineering" is not a free lunch in many industries, timely duplication of a major patented new product was reported to be impossible in only 12 of the 127 surveyed industries.

Nonetheless, there are several reasons why competitive imitation might be impeded even without patents, leaving sufficient incentive for investments in R&D. To imitate, one must know about the innovation and its advantages, and knowledge is always imperfect. Once a new technology is made public, it takes time for potential imitators to learn about it and decide whether it is worth copying. Studies of the diffusion process reveal that adoption spreads, first slowly and then more rapidly. Mansfield[19] found the pace of imitation to be positively correlated with the profitability of adopting the new technology. For product innovations, this means that the pace of imitation is a variable under the innovator's control. Companies pricing their new products to make a quick killing will encourage rapid imitation,[20] while those pursuing dynamic limited-pricing strategies may be able to retain sizable market positions for a considerable period.

This conclusion is supported by the findings from several surveys of R&D executives, revealing quite uniformly that, in most industries, patents are not very important compared to other incentives for innovation. Levin et al.[21] asked 650 U.S. R&D executives to evaluate the effectiveness of alternative means of protecting the competitive advantages from new and improved products and processes. For both products and processes, the nonpatent strategic advantages from being an innovator were found to be

[18] Richard C. Levin, A.K. Klevorick, R.R. Nelson, and S.G. Winter, 1987, *op. cit.*

[19] Edwin Mansfield, *Industrial Research and Technological Innovation*. New York: W.W. Norton, 1968.

[20] Mansfield et. al. found that 60 percent of the successful patented innovations were imitated within four years. See, E. Mansfield, M. Schwartz, and S. Wanger, "Imitation Costs and Patents: An Empirical Study", *Economic Journal*, 91, 1981: 907-918.

[21] Levin et al., 1987, *op. cit.*

substantially more important than patent protection. R&D executives placed greatest stress on product patent protection in the pharmaceutical industry, agricultural chemicals (for example, pesticides and herbicides, subject to analogous U.S. federal testing regulations), and industrial organic chemicals.

Mansfield[22] asked the chief R&D executives of 100 U.S. firms what proportion of the inventions they developed during 1981 through 1983 would not have been developed had they been unable to obtain patent protection. The pharmaceutical industry group came out on top with 60 percent, followed by chemicals with 38 percent, petroleum with 25 percent, machinery with 17 percent, fabricated metal products and electrical equipment about 11 percent, while for groups such as primary metals, instruments, office equipment, motor vehicles, rubber products, and textiles the score was close to 0 percent. Earlier surveys yielding similar results for the United Kingdom[23], and for Germany[24]. Thus, optimal patent policy can vary across industries.

In sum, a world without patents quite clearly would not be a world without innovation. Other incentives for innovation would fill most, but not all gaps. The influence of other factors on the propensity to innovate is presented in Annex B. Some inventions would, however, be lost, especially when the output of R&D is mostly information on whether the product works, with respect to which free riding is easy.

- *Is the Patent an Appropriate Protection System?*

Although devised to solve an important incentive problem, the patent system can be a crude and imperfect instrument. Patent protection is of the wrong kind when the project is complex and different firms hold patents on different parts of the entire innovation. Firm B may patent an improvement on firm A's invention, or firms C and D may each hold patents on diverse features, all of which a state-of-the art product should ideally incorporate. Each firm can block the other from using its patented part of the technology. Too long a patent term in this scenario would act as a disincentive to subsequent innovators. On the other hand, the holders of complementary patents often agree voluntarily to cross license each other. This enables all to achieve state-of-the-art

---

[22] Edwin Mansfield, "Patents and Innovation: An Empirical Study", *Management Science*, 32, February 1986: 175.

[23] C.T. Taylor and Z.A. Silberston, *The Economic Impact of the Patent System*. Cambridge: Cambridge University Press, 1973.

[24] Klaus Grefermann, K.H. Openlaender, et al., *Patentwesen und technischer Fortschritt*. Teil I. Goettingen: Schwartz, 1974.

technology, but lessens the exclusionary power of patents.

The patent protection is the wrong kind if cross licensing agreements can be used as a fulcrum for industry wide price-fixing and entry-excluding cartels that suppress competition more than would have been possible if each firm had independently exploited its own patented technology. A patent holder's power to block the use of its inventions by others poses a special problem in small economies and LDCs.

Economy-wide efficiency may suffer from patent provisions that are too strong. Excessive monopolization through a series of patents could enable such a patentee to place onerous conditions on licensees and potential competitors. Too strong patent protection would also divert resources into R&D activities beyond the optimal desirable level. If, for example, there is limited availability of skilled people and risk taking entrepreneurs, then a stronger patent protection would result in increased demand for these factors in industries where the patent protection is effective. In other words, too strong patents would drive up the cost of doing R&D in all sectors of the economy. Moreover, the administrative costs of enforcing a patent system may be significant, including the private and public costs of litigation.

It is often argued that the absence of patents might have particularly serious negative effects for independent inventors and fledgling firms. On this, the evidence is sparse, but offsetting tendencies can be identified. Small firms are at a severe disadvantage trying to claim patent rights and enforce them against large rivals better able to sustain the multimillion-dollar costs of protracted patent litigation. Thus, even though they need patent protection as much as the well-established companies, the protection they actually receive may be more fragile.

- *Patents, Innovations, R&D, and Returns*

Patents can be used as a measure of innovative activity across different firms, especially in the long run.[25] There is a strong relationship between patent numbers and R&D expenditures, and this relationship is close to being proportional. Mansfield[26] finds that, for the major firms in the petroleum, steel, and chemical industries in the United States, a positive relationship exists between innovative activity and R&D expenditures.

[25] Zvi Griliches, "Patent Statistics as Economic Indicators: A Survey", *Journal of Economic Literature*, Dec. 1990: 1661-1707.

[26] E. Mansfield, 1968, *op. cit.*

Pakes and Griliches[27], dealing with firms operating in U.S. manufacturing, also estimate a positive significant relationship between patents and R&D expenditures. There is a positive correlation between patents and R&D expenditures, but it is imperfect, as some innovations go unpatented. In Canada, McFetridge, using the Mansfield framework, found a significant positive relationship between patents and R&D expenditures and a negative relationship between patents and sales for the electrical, chemical, and machinery industries.[28]

The value of a patent declines if its exclusivity is eroded and it becomes obsolete by subsequent advance in knowledge. Pakes and Schankerman[29] used European data and found that the obsolescence rate of patents was on the order of 25 percent per year. R&D on durable goods in their sample data became virtually obsolete in 10 years on average and on nondurables in 8.5 years. The estimates of private return on R&D varied between 8 and 17 percent in their sample. If the normal (net) rate of return to physical capital is taken from Griliches[30] to be 8 percent, then Pakes and Schankerman estimates imply risk premiums for investment in research between zero and 9 percent. In view of the abnormal riskiness associated with research expenditures, these risk premiums appear modest. Thus, the carrot bait of high return on R&D turns out not to be as juicy as it may appear on the first bite.

[27] A. Pakes and Z. Griliches, "Patents and R&D at the Firm Level: A First Look". In *R&D, Patents and Productivity*, edited by Z. Griliches. Chicago: University of Chicago Press, 1984.

[28] Donald M. McFetridge, *Government Support of Scientific Research and Development: An Economic Analysis*. Toronto: Ontario Economic Council, 1977.

[29] Ariel Pakes and Mark Schankerman, "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources". In *R&D, Patents and Productivity*, edited by Z. Griliches. Chicago: University of Chicago Press, 1984: 73-88.

[30] Zvi Griliches, "Returns to Research and Development in the Private Sector". In *New Developments in Productivity Measurement and Analysis*, ed. J.W. Kendrick and B.N. Vaccara. Chicago: National Bureau of Economic Research, 1980.

B. Diffusion of New Knowledge and Technology

Technology diffusion is the spread of technology from its source—the inventor or innovator—to its users. The sources of innovation are concentrated in a few industries, while use is much less concentrated. For example, Seguin-Dulude[31] (1982) finds that in Canada, four industries (machinery, electrical products, chemicals and "other" manufacturing) were the industry of manufacture in 80 percent of the patents issued in 1978. The four largest users (machinery, transportation equipment, electrical products and chemicals) accounted for 49 percent of use.

Empirical studies show that only a small fraction of industrial R&D is oriented toward improving products that will serve solely as consumer goods. Innovations in one industry spread to other industries and improve related products and production processes. Resources can be wasted in the premature adoption of new technologies just as easily as they can be wasted in putting it off for too long. Nor does early adoption necessarily imply its earlier diffusion domestically. Indeed, Nasbeth and Ray[32] and Swann[33] have noted domestic diffusion rates are generally faster in the countries that adopt late.

In Canada, Globerman found that in numerically controlled machine tools in the tool and die industry[34], and computers in hospitals[35], the adoption of new technologies has proceeded more slowly in Canada than in the United States. There is also evidence that the intra-industry diffusion process in Canada[36] is facilitated by larger firm size, R&D

---

[31] L. Seguin-Dulude, "Les flux technologiques interindustriels: une analyse exploratoire du potential canadien". *L'Actualite Economique*, 58, 1982: 259-81.

[32] L. Nasbeth and G. Ray, eds., *The Diffusion of New Industrial Processes*. London: Cambridge University Press, 1974.

[33] P.L. Swan, "The International Diffusion of an Innovation." Journal of Industrial Economics 22, 1974: 61-69.

[34] S. Globerman, "Technological Diffusion in the Canadian Tool and Die Industry", *Review of Economics and Statistics* 57, November 1975: 428-34.

[35] S. Globerman, "The Adoption of Computer Technology in Selected Canadian Service Industries." A study prepared for the Economic Council of Canada. Ottawa: Minister of Supply and Services Canada, 1981.

[36] Donald G. McFetridge and Ronald J. Corvari, "Technology Diffusion: A Survey of Canadian Evidence and Public Policy Issues". *In Technological Change in Canadian Industry*, volume 3 of the research studies prepared for the Royal Commission on the Economic Union and Development Prospects for Canada. Toronto: University of Toronto Press, 1985.

expenditures, foreign ownership, and various measures of organizational receptivity to change.

The flow of technology can either be in the form of ideas and suggestions, or R&D can be embodied in the goods and services purchased by one industry from another. For Canada, De Melto et al.[37] used the flow of ideas and suggestions approach to study 283 innovations. In 96 cases, the technology came from outside the innovating firm. In 55 percent of these cases, the parent firm was the source of technology; the source was a supplier or customer in 19 percent of the cases; a consultant in 11 percent; and unaffiliated joint venture partners in 9 percent of the cases. Similar findings are confirmed by R&D intensity (R&D as a proportion of gross output) as a measure of inter-industry technology flows.

Although intra- or inter-industry technology diffusion must be measured for individual industries, the following generalizations for Canada can be made. The industries providing the greatest fraction of their own technological requirements are electrical products, machinery, chemicals and miscellaneous manufacturing. The industries providing the least are construction, agriculture, forestry and fishing, and, in manufacturing, leather, food and beverages, and textiles.

- *International Transmission of R&D*

Since knowledge generated from innovation is internationally available, countries benefit from all innovation, regardless of where it originates. In general, the gains from innovations are nonetheless greater in the innovating country than in countries that import the technology because of the increased jobs and higher wages associated with high-technology industries. In addition, the innovating country benefits from earnings on the sale or lease of new technology to other countries. If process improvements to an initial innovation are made in the innovating country, the benefits of the initial innovation are even greater over time for that country because of increases in productivity.

International diffusion of technology is primarily determined by factors such as market size (openness to trade), market structure, capital flows (openness to foreign investment), and information (information gathering and dissemination, including education). Empirical studies indicate that the United States appears to be the major source of technology transfer to Canada.[38]

[37] D.P. De Melto, K. McMullen, and R. Willis, "Innovation and Technological Change in Five Canadian Industries". Discussion Paper 176. Ottawa: Economic Council of Canada, 1980.

[38] D.P. De Melto, K. McMullen, and R. Willis, 1980, *op. cit.*

The diffusion of innovations, particularly process innovations, has historically been slow. Mansfield[39] argues that firms are often unwilling to license new technology abroad because it is difficult to control the diffusion of the technology in other countries. This licensing argument should not apply within firms, however. Multinational corporations (MNCs) typically do not sell their new technology to licensees. MNCs initially exported finished products, which embodied new technology and innovations. But MNCs have gradually changed their emphasis from solely exporting to local assembly or manufacturing in the host countries. The MNCs, with investments abroad in high-technology industries, such as IBM and Toyota, have significantly increased the pace of technological diffusion internationally. Local production in the host countries requires that new technology is transferred to subsidiaries much sooner than without the globalization of production by MNCs. The international process of innovation diffusion has, consequently, become shorter since 1965.

Daly and Globerman[40] have argued that in the past Canada's small, traditionally tariff-protected market has retarded both the initial adoption and the domestic diffusion of scale-oriented innovations. The technology transfer lags are relatively short with intra-corporate transfers. The implication of this is that restrictions on multinationals by host governments can have the effect of deterring or at least postponing the transfer of the most sophisticated technologies to the country. If the intra-corporate mode is cut off, it may be a long time before the arm's length alternative is sufficiently profitable to justify the transfer. International diffusion lags will be greater in the cases of countries which heavily screen foreign investment or maintain equity controls. Thus, policies favoring free capital flows reduce international diffusion lags. Policies restricting capital flows or otherwise making the local environment appear less hospitable (e.g., an intellectual property regime that falls short of the international norm) will discourage investment. Since the United States, and U.S. based MNCs, are our major source of technology transfer, it is important that Canadian subsidiaries have continuous accessibility to such technology transfers.

[39] Edwin Mansfield, "R&D Innovation: Some Empirical Findings." In *R&D, Patents and Productivity*, edited by Z. Griliches. Chicago: University of Chicago Press, 1984: 127-48.

[40] D.J. Daly and S. Globerman, *Tariff and Science Policies: Applications of a Model of Nationalism*. Toronto: University of Toronto Press, 1976.

Globerman[41] investigates the spillover effects of foreign-owned firms on their domestic counterparts in the same country. He finds that labor productivity in domestically owned manufacturing plants in a given industry is an increasing function of the degree of foreign ownership in the industry. He interprets this as supporting the notion that foreign direct investment entails spillover efficiency benefits. Mansfield[42] finds that the rate of productivity growth of U.S. firms is an increasing function of their overseas R&D expenditures. This implies that R&D conducted by foreign affiliates and perhaps supported by foreign governments spills over to the benefit of the U.S. parent.

We now turn to the theory of optimal patent term in a trading economy.

[41] S. Globerman, "Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries", *Canadian Journal of Economics*, 12, February 1979: 42-56.

[42] E. Mansfield, 1984, *op. cit.*

II.3. THE THEORY OF OPTIMAL PATENT TERM IN A TRADING ECONOMY

> By employing improved machinery, the cost of production of commodities is reduced, and, consequently, you can afford to sell them in foreign markets at a cheaper price.
>
> -David Ricardo in *Principles of Political Economy.*

Patent protection in an international context is different for product and process innovations. For product innovations, patent protection can occur at the point of consumption if imitators can be prevented from selling unauthorized patented products. Thus, the ability of the patentee firm to enforce its right in the importing country is crucial to whether the foreign owner of patented innovation can appropriate the rents in the domestic market. In the case of process innovations, however, the enforcement of patent protection at the consumption end is less effective, since the origin of products manufactured by such a process can be easily disguised. In this case, effective patent protection requires protection at the production end rather than at the consumption end. This distinction is important if different patent rules apply in different countries, or if the rules are enforced differently.

To bring out the space and time dimension of the patent system in an international economy, let us begin by analyzing an extreme situation. Consider a single, large and high-income market such as the U.S., where patent rights exist. The monopoly pricing will induce a certain level of R&D. But the situation is suboptimal in two ways. Consumers' choices are restricted by monopoly pricing and the innovators fail to earn profits equal to the entire benefit to society[43] that is generated by their innovations. These two aspects of suboptimality give rise to both the benefit and the cost of extending patent protection to a larger, or an additional, market.

Consider Canada as the additional market that has not previously granted patent protection to U.S. innovators. The U.S. R&D firms gain additional monopoly profits by selling in Canada. On account of these higher returns, the U.S. firms increase R&D done in the U.S. U.S. welfare will improve beyond its previously suboptimal level. There will be benefits and costs in Canada. Canadian consumers gain access to new products. If the

[43] In terms of Figure 1 above, the consumers' surplus (given by the area below the demand curve and above the P_0A line) is not appropriated by the innovator.

U.S. technology was denied to Canadian firms in the pre-patent scenario and is accessible with the patent, then extending patent protection is unambiguously welfare improving for both the U.S. and Canada. However, if the innovative foreign products and technology had been available in Canada without patent protection, there would now also be a cost. Monopoly pricing would reduce consumption, relative to the unprotected market, to a suboptimal level in Canada. The effect of extending patent protection in Canada, in this case, is to transfer a part of the welfare of Canadian consumers to the U.S. monopoly-innovators.

The benefits from extending the protection arise entirely from the new R&D that is made profitable in this additional market, but which would not have been profitable in the U.S. market alone. In general, the larger the previously protected market, the greater will be the number of innovations already undertaken, and the less desirable will be the ones that remain. Hence, the incremental benefit of R&D projects undertaken declines.

The cost of extending patent protection to this additional market is the amount by which consumers' benefit is reduced by the monopoly price and the monopoly profits earned on the innovations (which are transferred to the innovator in the U.S.). As patent protection is extended further, and as more and more R&D projects are stimulated, these losses add up.[44] However, in this extreme case, we did not factor in the possibility that patent protection for process innovations is difficult to enforce. In practice, U.S. innovators taking out patents in Canada will transfer technology from the U.S. and manufacture the product in Canada. The benefits of the technology transfer, discussed in section II.2(B) above, will offset the costs of higher consumer prices and the transfer of rents to the U.S.

Berkowitz and Kotowitz[45] (BK, henceforth) develop a model, much in line with the above discussion, for a small trading economy. In determining a fixed optimal patent term policy, the country maximizes welfare[46] of its residents and ignores externalities conferred by foreign technology. In a world characterized by a uniform patent term of T years, the

[44] Alan V. Deardorff, "Should Patent Protection Be Extended to All Developing Countries?" *The World Economy*, 13 (4), December 1990: 497-507.

[45] M.K. Berkowitz and Y. Kotowitz, "Patent Policy in an Open Economy", *Canadian Journal of Economics*, 15(1), 1982: 1-17.

[46] The welfare in the economy is defined as (a) the gross benefits to local innovators from the world-wide patent and the local patent rights during the local patent period plus the benefits during the time between expiration of the local patent and expiration of the global patent; plus (b) the gain to local producers from their ability to utilize the innovation after the local patent expiration, but prior to expiration of the patent elsewhere; plus (c) local consumers surplus at the global expiry of the patent due to the lower world price, and minus (d) the cost of local resources spent on innovation in the relevant industry.

country is assumed to ignore foreign retaliation of its actions. Consumption patterns in this country are assumed to be similar to those of the rest of the world. The analysis considers only run-of-the-mill process innovations. Product markets are assumed to be competitive. BK analyze the implications on the optimal patent term of both monopoly and competition in the innovation industry, the latter being the more realistic situation in a trading country. The following cases can be distinguished.

Case 1: Many inventors in a competitive international market.

Taking Canada as a small trading economy, BK assume a perfectly competitive market. Net social benefits to Canada from the patent system, under these assumptions, consist of (a) benefits to producers between the expiration of the patent in Canada and its expiration in other countries, and (b) net benefits to consumers after that. Private benefits to innovators, whether Canadian or foreign, are irrelevant in the BK model because competition among innovators dissipates the entire appropriable rents. Spillovers from innovations are not part of the analysis.

In this case, with many inventors racing to obtain patent rights, the BK theory holds that *it is beneficial for Canada to provide very little or no patent protection.* Given that there is patent protection in the rest of the world, and private benefits to innovators are ignored, a patent regime in a small economy has no effect on incentives to do R&D in that economy. Even very large countries will find it profitable not to have a patent system.

Case 2: One inventor in a competitive international market.

In this case, the monopolist inventor is able to appropriate rents in the product market by owning the patent. BK assume that multinationals register patents in the name of the head office, regardless of the location of the R&D or the innovation. Again, spillover effects of innovations are ignored. However, the optimal patent life depends on the ownership of the innovations.

- **Invention occurs in Canada and is owned by Canadians.**

Consider, for instance, that Northern Telecom invents a new switching system and applies for a patent in Canada. In this case, the BK model suggests that no matter what the patent term happens to be in other countries, *it is beneficial for Canada to have a patent term that is longer than in other countries.* Canada's share of the market for the switching system will increase and R&D in this sector where we have clear expertise will be further stimulated as the patent term is increased.

- **Invention occurs in Canada but is foreign-owned.**

Although subsidiaries of foreign-owned multinationals perform R&D in Canada, the patent right still resides with the parent company. Consequently, it is assumed in the BK theory that only the parent country benefits directly from any monopoly profits made by the innovator. Therefore, the BK theory concludes that *no patent protection* is warranted for foreign-owned companies based in Canada.

- **Invention occurs in a foreign country and is foreign-owned.**

When research and inventions take place abroad, and spillovers from innovations are not taken into account, neither benefits to innovators nor their expenses are relevant from Canada's point of view. In this theoretical case, the BK model suggests that *it does not pay any single country to protect innovations* of foreign-based and controlled corporations.

Thus, the differences implied by competition and monopoly in the innovation industry, and the ownership of innovations result in conflicts in the determination of patent policy. The industrial structure of invention may differ in different industries, calling for drastically different patent policies. If any degree of monopoly in innovations exists, such power may reside in multinationals. The BK model suggests that no patent protection is warranted under most circumstances. Moreover, the BK analysis suggests that stipulations by local governments on the performance of R&D in local subsidiaries of foreign companies are largely useless, unless the government can ensure that patent rights (and appropriate royalties) reside in the local subsidiary as well.

III

THE PATENT REGIME IN CANADA

The Patent Act is administered by the Patent Office. Originally, the life of the patent was 14 years from the date of the grant. Subsequently in 1969, it was extended to 17 years. Presently, it is 20 years from the date of application.[47] In 1990, Canada granted 14,944 patents to innovators and 16,248 in 1991. In each of the two years, about 11.6% of all patents were taken out by individuals, and of all the patents granted in Canada, 92.7% were taken out by foreigners.[48] In 1982, of all the patents granted in Canada, 93.8% were held by foreigners. In 1982, in the tally of granting patents to innovators, Canada (with 22,447 patents) stood at 5th place in the world.[49] Because the proportion of patents held by foreigners in Canada is relatively high, each year a significant sum passes out in the form of royalty payments to foreigners for the use of patent rights. However, this situation is not peculiar to Canada.[50] It reflects that Canada, as a dynamic economy, imports advanced technology. However, a high proportion of patents are apparently not worked—either in Canada or in other countries. This may reflect the fact that many patented innovations become obsolete shortly after the patent grant or are not economically feasible.

[47] Consumer and Corporate Affairs Canada, *Annual Report*, Year-end March 31, 1992, Government of Canada, Ottawa: p. 23.

[48] Moreover, of all the patents granted to foreigners in Canada, the United States share rose from 53% in 1990 to 54% in 1991; the Japanese share went up from 13.4% in 1990 to 14.2% in 1991; and the German share declined from 8.3% in 1990 to 7.8% in 1992. Source: Consumer and Corporate Affairs Canada, *Annual Report*, Year-end March 31, 1992, Government of Canada, Ottawa, *op. cit.*

[49] Behind the United States (57,889 patents granted), Japan (50,601), the United Kingdom (29,590), and France (23,944); and ahead of West Germany (16,306), Brazil (10,074), Switzerland (9,627), and Sweden (7,864). The survey excludes the former Soviet Union. Source: World Intellectual Property Organization (WIPO), *100 Years Protection of Intellectual Property: Statistics, 1883-1982*, Geneva, 1983.

[50] In 1982, foreigners received 84% of the patents issued in the United Kingdom; in Switzerland foreigners held 80%; in France they held 68%; foreign-owned patents accounted for only 17.3% of all patents granted in 1981 in Japan; and for 41% in the United States in 1982. Source: WIPO, 1983, *op. cit.*

The Pharmaceutical Industry in Canada

There is a large presence of multinationals in the Canadian pharmaceutical industry. The majority of the leading firms engage in research and development in Canada and hold patents for their inventions. The industry in Canada consists of approximately 150 manufacturing establishments comprising brand-name and generic companies, with almost $3.8 billion in domestic shipments in 1990. The generic manufacturers are chiefly Canadian-owned. The industry is concentrated in Ontario and Quebec. In 1990, the pharmaceutical industry in Canada exported less than 7 percent ($231.4 million) of its shipments. Imports accounted for almost 23 percent ($947.9 million) of the total Canadian market for pharmaceuticals. The industry is relatively small, accounting for less than 2 percent of all shipments, employment, investments and value-added in the total manufacturing sector. It accounted for 7.1 percent of R&D in manufacturing in 1990.[51]

While other industrialized countries relied on direct economic regulation to affect the price and innovation performance of the pharmaceutical industry, Canada opted for a different approach: limitation of intellectual property rights. Since 1923, Canada's *Patent Act* had allowed compulsory licenses to be obtained for the manufacture, use and sale of patented processes. However, relatively few licenses were granted: only 11 of a total of 53 compulsory license applications, made between 1935 and 1970, were granted.

In the 1960s, there was considerable concern that medicine prices in Canada were high in relation to both production costs and prices in many other industrialized countries, which brought forth strong official reaction. In June 1969, Parliament amended the Patent Act to allow firms to be licensed to import and/or manufacture pharmaceuticals for which patents were held in Canada. The licensees paid an arbitrarily set royalty of 4 percent to the patentee and could begin the manufacture and sale of a patented medicine. The licensee thereby entered into direct competition with the patentee, by selling low-cost "generic copies" of patented medicines. The idea was that, by weakening patent protection and speeding up diffusion of pharmaceutical innovations, consumers would enjoy lower pharmaceutical prices in Canada. The compulsory licensing policy was successful in reducing medicine prices. A study[52] found that, on average, the price of compulsorily licensed medicines sold to pharmacists fell from 86 percent of the U.S. price in 1968 to 45

---

[51] Patented Medicine Prices Review Board, *Fourth Annual Report*, Ottawa: Minister of Supply and Services Canada, 1992.

[52] Myron J. Gordon and David J. Fowler, *The Drug Industry: A Case Study of the Effects of Foreign Control on the Canadian Economy*, Canadian Institute for Economic Policy, Toronto: James Lorimer & Co., 1981.

percent in 1980, a finding consistent with other studies.[53]

However, by the 1970s Canada stood alone among its major trading partners in its approach to compulsory licensing for patented pharmaceuticals. The provisions were seen as a violation of the principle that an innovator has a right to an adequate period of protection for what he or she has worked on, invented, and developed. As Canada entered the 1980s, the federal government faced a deepening dilemma. On the one hand, Canada's trading partners (France, Germany, Sweden, Switzerland, the United Kingdom and the United States) had made it clear that the offending provisions of the Patent Act were unacceptable. The anomaly undermined efforts to reinforce Canada's image as a preferred site for investment and discouraged R&D expenditures in Canada by the pharmaceutical industry. On the other hand, application of the compulsory licensing system had been successful in lowering Canadian drug prices relative to those in the United States (thus helping to control costs for the health care system) and in promoting a thriving Canadian generic drug industry.

In 1983, the federal government set up a Commission of Inquiry to examine the pharmaceutical industry in Canada. The Eastman Commission reported back in 1985 with its recommendations. In 1987, Bill C-22 increased the patent protection for pharmaceutical firms. For new patented medicines, a compulsory license could not be exercised, in practice, for 7 years after the medicine had been approved for sale in the market. This time interval is referred to as the period of exclusivity. In exchange for extended patent protection, the Canadian pharmaceutical industry undertook to double its ratio of R&D to sales by the end of 1996. The effect of these provisions is to assure patentees the exclusive right to market a new medicine in Canada. Moreover, the Patented Medicine Prices Review Board was established in 1987 as well. The Board's regulatory function is to ensure that the prices of patented medicines charged by patentees are not excessive. In December 1992, compulsory licensing was eliminated. This change makes Canadian practice consistent with the well-established international standard.

[53] See Paul K. Gorecki, *Regulating the Price of Prescription Drugs in Canada: Compulsory Licensing, Product Selection, and Government Reimbursement Programmes*, Technical Report No. 8, Ottawa: Economic Council of Canada, 1981; J.J. McRae and F. Tapon, P.K. Gorecki, D.G. Hartle, "Compulsory Licensing of Drug Patents: Three Comments", *Canadian Public Policy*, X(1), 1984: 74-87; Joel Lexchin, "Pharmaceutical, Patents and Politics: Canada and Bill C-22", *The Canadian Centre of Policy Alternatives*, 1992.

The Patent Term Extension and the Effect on Innovations

The task of testing whether an extension of the patent term has any innovation stimulating effects would appropriately require a detailed estimation of costs and benefits of such a policy on Canadian industries. At present, there appear to be no cost-benefit studies in the literature and such an exercise is beyond the scope of this Paper. Nevertheless, recent developments in the pharmaceutical industry in Canada present an opportunity of a quick and best guess check. However, firmer conclusions cannot be drawn unless cost-benefit estimates on an industry basis are compared.

Recall that in Section II.2, it was argued that researchers have found a positive relationship between (a) patents and R&D expenditures, and (b) sales and patents. In this Paper, I propose to use the ratio of R&D expenditures and total sales to check the relationship between patent term extension and innovations.

Recall that economic theory predicts that in a non-trading economy, "hard" and "major" innovations would merit longer patent terms than "easy" and small innovations. The evidence on the importance of patent term from earlier studies, discussed in Section II.2, is that patents matter most in the pharmaceutical and other chemical industries. On the other hand, in a trading economy, the Berkowitz and Kotowitz (BK) theory, as discussed in Section II.3, predicts that there are no benefits from having a patent system in a trading economy. If a patent term of zero years is optimal and it obtains an efficient level of innovations, then the BK theory would suggest the following hypothesis: *In a trading country, any extension in the patent term from zero years will not confer positive benefits of increased innovations in the economy.*

The stimulus to innovations of an extension in the patent term depends on whether the period of effective market protection has been increased or not. From 1969 to 1987, generic firms could obtain compulsory licenses anytime, but in practice on average about four years elapsed before the generics came on the market; i.e., prior to 1987 a patentee had on average four years of effective market exclusivity. In 1987, the effective average patent protection increased to about seven years.[54] In other words, the effective market exclusivity to the patentee in the pharmaceutical industry increased by approximately three years.[55] If the BK theory is correct, then such an extension in effective patent term should not lead to a significant increase in innovations as measured by the R&D and sales ratio.

[54] Industry, Science and Technology Canada, *The Benefits of Bill C-22*, Government of Canada, Ottawa, 1992.

[55] The effective patent term is illustrated in the time-line charts found in Annex C.

The evidence from the Canada-based pharmaceutical industry shows that R&D outlays (net of marketing costs) as a proportion of total sales declined from 5 percent in 1983 continuously during the 1980s, only to return to 5 percent by 1988.[56] The ratio had increased to 8 percent in 1990 and to 10 percent in 1991.[57] Clearly, the 1987 patent term extension has contributed to an increase in innovations as measured by the R&D to sales ratio in the pharmaceutical industry in Canada. On the cost side, the average annual rate of price increase of patented medicines from January 1987 to December 1991 has been 2.9 percent, while the Consumer Price Index rose by 5.6 percent.[58] A doubling of R&D as a proportion of sales compared with a mere 3 percent annual increase in prices is clearly a favourable trade-off. This calculation suggests that the BK hypothesis of no patent protection benefitting Canada cannot be accepted. There appear to be overall benefits in the pharmaceutical industry from the patent extension in 1987.

The Canadian experience in the pharmaceutical sector raises serious questions about the policy relevance of conclusions drawn solely from economic theory as described in chapter II above. Until better theories are available, this Paper recommends that Canada continue to follow international norms with respect to the patent term, although without encouraging any further across-the-board extension of its current length.

[56] Industry, Science and Technology Canada, *The Benefits of Bill C-22*, Government of Canada, Ottawa, 1992. These R&D outlays include both clinical testing and basic R&D.

[57] Patented Medicine Prices Review Board, 1992, *op. cit.*

[58] Patented Medicine Prices Review Board, 1992, *op. cit.*

IV

INNOVATION AND PATENT TERM IN NEW GROWTH THEORY

> It is indeed the source of the superiority of the market order, and the reason why, when it is not suppressed by the powers of government, it regularly displaces other types of order, that in the resulting allocation of resources more of the knowledge of particular facts will be utilized which exists only dispersed among uncounted persons, than any one person can possess.
>
> F.A. von Hayek[59]

The determination of the optimal patent term, whether in a non-trading or trading economy, in the present state of economic theorizing completely ignores beneficial externalities conferred by innovations in the economy. Empirical studies show that there are considerable spinoff benefits from industrial innovations.[60] Exclusion of these gains underestimates the value of innovations. Consequently, the value of patents and of patent duration is also downward biased.

Another limitation of the received theory is the assumption of perfect competition in the product market. Most manufactured goods are, however, traded in imperfectly competitive markets where a price in excess of the incremental cost of production is the rule rather than the exception. Whether the market system provides sufficient lure for firms to do R&D in such markets, and whether the patent term implications are any different as a result, is an issue we explore in this section.

[59] Friedrich August von Hayek, "The Pretence of Knowledge", Nobel Memorial Lecture, December 11, 1974. Reprinted in *American Economic Review*, 76-6, December 1989: 3-7.

[60] Jeffrey I. Bernstein and Ishaq M. Nadiri, " Interindustry R&D Spillovers, Rates of Return, and Production in High-Technology Industries", *American Economic Review* 78 (Papers and Proceedings), 1988: 429-434. Jeffrey I. Bernstein and Ishaq M. Nadiri, "Research and Development and Intra-Industry Spillovers: An Empirical Application of Dynamic Duality", *Review of Economic Studies* 56, 1989: 249-268.

• "New Growth Theory"

The new growth theory begins by incorporating the ingredients that are so far missing in our formal analysis of the patent term. Traditional growth theory did recognize the importance of technical change and innovation as a contributing factor to economic growth, but innovation was not central to the analysis and the dynamics of growth in the economy. The new growth theory accords innovation and the resulting beneficial spillovers a central role in the dynamics of economic growth. Innovations are the motor of economic growth. R&D are key inputs to the most dynamic sectors of the economy such as robotics, pharmaceuticals, telecommunications, and even traditional sectors such as automobiles.

Each firm can accumulate knowledge, just as it can accumulate capital. The more knowledge it accumulates, the greater is its output. Each firm's own knowledge is like a type of capital. Savings are devoted both to the accumulation of physical capital and to the accumulation of knowledge. But knowledge, like physical capital and labour, is subject to diminishing returns. So profit maximizing firms choose that level of 'knowledge' to employ which equates marginal product of knowledge to its marginal cost.

Economy-wide, or aggregate, knowledge is the sum of what every firm and worker knows. The output of each firm depends on this aggregate stock of knowledge. Simply because there are other knowledgeable firms and workers around, an individual firm can produce more.[61]

When a firm decides how much knowledge to accumulate, it evaluates the effects of its decision on its own profits. It does not take account of the fact that its own accumulation of knowledge will bring benefits to other firms. Economy-wide knowledge is an **externality**, a cost or benefit experienced by one economic agent that results from the actions of another agent or agents. Because economy-wide knowledge is an externality, when one firm invests resources in advancing its own knowledge, it is at the same time expanding the production possibilities of all the other firms in the economy as well. As a result, for the whole economy there are **increasing returns** to knowledge. Increasing returns occur when the marginal product of 'knowledge' increases as the quantity of 'knowledge' increases, other inputs held constant.

[61] Paul M. Romer, "Endogenous Technological Change", *Journal of Political Economy*, 98, 1990: S71-S102.

The presence of externalities and increasing returns to 'knowledge' make it possible for a large and rich economy to grow indefinitely at a faster pace than a small and poor economy. They also make it possible for an economy to grow at an increasing pace as it becomes larger and richer. The opportunities that exist in rich countries with a large and highly skilled labor force working with advanced technologies are not so widely or readily available in poorer countries. In such countries, a much smaller proportion of the work force has the skills necessary to take advantage of new technologies.

Product improvement occurs in a slew of sectors. At a given point in time, each sector can either have a quality leader who serves the entire market, or it can have an arbitrary number of oligopolists competing on prices. Product quality improvements depend on innovations and the R&D intensity. By improving a good, an entrepreneur gains a competitive edge in the market and captures a segment of the market. This temporary monopoly ensures that the innovator can reap the rents and offset the costs for R&D. Furthermore, progress is not uniform across sectors due to the random nature of innovations.

The innovation process can be characterized by the externalities it generates. Grossman and Helpman[62] (GH, henceforth) identify two effects: (a) a consumer-surplus effect, which describes the positive externality bestowed upon consumers from successful innovations and advanced product quality; and (b) a business-stealing effect, which captures the negative externality imposed on a rival firm when an innovator reduces or eliminates the producer surplus of the rival firm it displaces. Let me illustrate the dynamics briefly.

IBM brought to market micro personal computers (PCs) at substantial upfront cost in R&D. On account of its entrenched position in business computers and being the first mover in PCs, IBM made above normal profits. These profits soon attracted entry by imitators who simply did "reverse engineering" and came out with IBM-compatible hardware at lower prices. The new knowledge of producing PCs spills over in rest of the industry and other related industries. Lower unit costs come about on account of economies of scale in the new knowledge using industries. The PC market is an imperfectly competitive one where firms are making positive economic profits. IBM responds to the whittling away of its profits by speeding up R&D efforts and brings out an advanced second generation PC to maintain its "top dog" position. Its rivals in the imperfectly competitive market follow suit. The cycle repeats itself with greater force, as the intensity and speed of R&D activity increases each time. Innovations in such an industry are generated by the interplay of forces within the market itself.

[62] Gene M. Grossman and Elhnan Helpman, 1991, *op. cit.*

Combining the two features, spillover benefits of innovations through diffusion of new knowledge economy-wide and increasing returns to scale that result in above-normal profit-generating, imperfectly competitive international markets, the pattern of trade is determined. A country that is well endowed with human capital specializes relatively in performing (human capital intensive) R&D and develops a comparative advantage in high-tech manufacturing. At the same time, a country with an abundance of unskilled labor devotes relatively few resources to industrial research and ultimately finds itself importing high-technology goods and exporting traditional manufactures.

- **"New Growth Theory" and the Patent Term**

In the GH theory, entrepreneurs invest resources in order to develop unique goods. "Product designs are assumed to be proprietary information, either because their details can be kept secret or because *patents* effectively deter unauthorized uses."[63] GH also assume that innovators can appropriate the returns to product innovations which enable them to manufacture new products, but not the returns to general knowledge (applied science) which serves as an input in the innovative activity. The diffusion of innovation is central to international spillovers through trade in commodities and to long-run comparative advantage.

The institution of patents is thus essential in the new growth theory. What is the optimal patent term in these models? Without formally setting up the model, it is clear that the diffusion of innovations can only take place if the patent term is shorter rather than longer. Also, the successive cycles of innovations make the earlier generation of products and the innovations they embody obsolete. This was illustrated in the computer example above. This is a significant modification of the Berkowitz and Kotowitz conclusion that no patent system is in the interest of trading economies. Even a small trading economy would have to provide IP protection if it wants to benefit from international technology inflows. Otherwise, advanced countries will pass it by.

Thus, the theory of the optimal patent term must be integrated into the "new growth theory". One result is that the BK conclusion is modified: *A positive but not necessarily a long patent term is optimal for a trading economy.*

[63] Gene M. Grossman and Elhnan Helpman, 1991, *op. cit.*, p. 43.

V

THE SCOPE OF A PATENT

Patent length is, however, only one aspect of patent protection. Another important trade policy question is: What is the optimal *scope* of patent protection? The scope of patent includes considerations of patent breadth. For example, the inventor of the oversized Prince tennis racket[64] was granted U.S. patent protection for 85 to 130 square inch rackets[65]. Competitors were forced to produce outside this range. But other countries may choose to enforce narrower patent widths than the U.S. The allowable breadth of claims is determined by patent examiners and the judiciary. Indeed, Prince failed to obtain useful patent protection in England, Germany or Japan.

Wider patents reduce consumers' freedom to substitute competitively marketed, unpatented varieties of the product. Narrow patents reduce profits that an innovator can appropriate. In providing adequate profit reward to the innovator at the least social cost, there emerges a trade-off between patent width and patent length. Depending on market demand, long-lived and narrow, or short and wide patents can be optimal.[66]

If a patent is given a narrow interpretation, the innovator's competitors will have an easy time "inventing around" an existing patent and still will not be penalized for patent infringement. Imitators will incur the cost of reverse engineering and come out with a product variety similar to that of the innovator. Consumers will have the choice of lots of variety and the imitators will bite into the innovator's rents. Thus, narrow patents reduce profits that an innovator can appropriate. Wider patents reduce consumers' freedom to substitute competitively marketed, unpatented varieties of the product, and can preserve most of the rents for the patentee.

This Paper argues that the scope of a patent can be exploited by some countries given that patent terms have converged among industrialized countries. Consider an

[64] Howard Head of Prince Manufacturing, see Paul Klemperer, "How broad should the scope of patent protection be?", *RAND Journal of Economics*, Spring 1990: 114.

[65] The conventional racket face at the time was 70 square inches.

[66] Richard Gilbert and Carl Shapiro, "Optimal Patent Length and Breadth", *RAND Journal of Economics*, 21(1), Spring 1990: 106-112.

industry in a country bound to a 20 year patent term by international agreements. The industry claims that the patent term protection is not adequate and the domestic patent authorities also concur with the industry that the socially optimal patent term ought to be longer. The patent adjudication institutions in this country could possibly exploit the scope dimension of the patent and give the patent a wider interpretation, which will increase the commercially effective impact of the patent to the patent-holder.[67] Since the scope dimension is open to interpretations, it has the potential of being abused by some countries either to attract R&D investment or to encourage imitation. It is one of the major recommendations of this Paper that trade policy analysis and negotiations should take into consideration the scope of patents in any future work.

Another aspect of patenting is that it sets off a race among potential innovators to win the patent prize. The prospect of developing and patenting the HDTV had set off a race among firms in Japan, Europe and the United States. To a large extent, these firms perform parallel R&D. From society's point of view, such duplication of R&D expenditures entails waste of economic resources. Sensing this, America's Federal Communications Commission (FCC) decided to pick an HDTV standard through a neutral technical competition and has chosen a technology consortium to do the job.[68] Thus, one way to minimize the dissipation of benefits from innovation is for competition authorities to permit the formation of research joint ventures.

Awarding only one broad patent to the first firm past the post makes R&D projects excessively risky from a social viewpoint. To increase its chance of winning the patent, each firm contributes to the acceleration of the race, which leads to dissipation of patent rents, as discussed in section II.1 above. One possibility to minimize the dissipation of these rents is to widen the scope of a patent by increasing the number of prizes and narrowing the interpretation of the protected idea. Awarding multiple patents in a product group consisting of similar but differentiated products will benefit consumers as well as innovators. Consumers will have more varieties to choose from and firms can market their products at prices higher than marginal cost. To the extent the present patent system rewards late finishers, it contributes to a socially preferred choice of research strategy.[69]

---

[67] The patent for oversized rackets could be interpreted to cover the range from 70 to 150 square inches, thereby eliminating domestic and import competition. See footnote 65 above.

[68] To avoid wasting future profits, firms comprising AT&T, General Instrument, Philips, Thomson, Zenith, the David Sarnoff Research Centre and the MIT have formed a "grand alliance" or a joint venture. See *The Economist*, May 29, 1993: 74.

[69] M. La Manna, R. Macleod, and D. de Meza, "The Case for Permissive Patents", *European Economic Review*, 33, 1989: 1427-1443.

The breadth of a patent also has important long-run or dynamic efficiency consequences. Early innovators confer externalities or spillovers on later innovators. A balanced patent system would reward early innovators fully for the technological foundation they provide to late innovators, and also reward late innovators adequately for their improvements and new products. If patent protection is broad, then inefficiently inflating incentives for the first innovator provides weak incentive for an outside firm to develop second generation products.[70]

One possibility that is open to second generation firms is to have licensing agreements after products have been developed and patents have been awarded. But from society's point of view, requiring every late innovator to license any underlying technology will give deficient incentives for outside firms to develop second generation products. Another way the outside research firms can integrate with initial patentholders is by forming cooperative research joint ventures. Joint ventures can increase the joint profit of the members and bring about greater efficiency by exploiting economies of scale, by sharing technological know-how, or by undoing the inefficiencies of a patent race. With a prior agreement, the initial patent-holder can agree to share both the costs and the proceeds of the second innovation, and will do so whenever benefits exceed costs. The breadth of patent protection also determines how joint profit of the research consortium will be split. From the long-run efficiency viewpoint, the best patent policy is not to make the patent protection of an initial innovator so broad that all later improved products infringe it, thus requiring licensing.

It should also be recalled that patent policy in many countries is prone to over-emphasize R&D. For many purposes, the important thing is innovation, not R&D, which by itself has little or no value. Many innovations are not based on any formal, sophisticated R&D. It is much more important for an economy to exploit a new technology successfully than to be the first to introduce it. In this view, diffusion or imitation of innovations may be much more important than innovations.[71] A country's policies concerning economic growth and investment, competition and protection, taxes and entrepreneurship have much more effect on its rate of innovation than its policies concerning R&D.

---

[70] Suzanne Scotchmer, "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law", *Journal of Economic Perspectives*, 5, Winter 1991: 29-41.

[71] Edwin Mansfield, "Technological Change and the International Diffusion of Technology: A Survey of Findings". In *Technological Change in Canadian Industry*, volume 3 of the research studies prepared for the Royal Commission on the Economic Union and Development Prospects for Canada. Toronto: University of Toronto Press, 1985.

- **Patent Policing: Scope and Litigation Costs**

Maintaining the patent owner's rights can entail (a) patent renewal fees and (b) costs of litigation in case the patent is attacked. In many countries, such as Germany, Austria, France, Great Britain, the Netherlands, Japan and Switzerland, the patentee is required to pay periodic renewal fees to maintain its rights. Canada instituted the renewal fee system in 1990. The United States in 1982. Germany and Austria in particular have traditionally enforced schedules under which the renewal fees escalate sharply as time passes. In Germany during 1986, for example, renewal fees during the first ten years of a patent's life cumulated to a total of DM2,375. However, by the end of the 20th year, a patent holder would have paid a total of DM22,375 to keep its patent in force.[72] A consequence of rising renewal fees is the weeding out of marginal patents - those whose value is less than the marginal cost of the fee.[73]

The questions of patent coverage, validity and infringement are important because they largely determine a patent's value. Settling these matters when challenged by a competitor requires the patentee to incur transaction costs through the litigation process. The value of a patent, when litigation is necessary, is equal to the present value of revenues from its exploitation minus the costs of acquisition and policing against infringement. Minimizing these transaction costs benefits everyone except patent infringers and licensees.

The definition or description of the patented product is central to the resolution of a dispute over patent infringement. A product is defined by its constituent parts or characteristics. Readily measurable characteristics define the patented product with precision. A patent infraction by competitors of a well-defined patented product, brought before the courts, can be settled in a short time and at a low cost. Common or hard to measure characteristics leave room for competitors to dispute the scope or width of the patented product.

A patented product that is commercially successful and whose scope can be disputed attracts copy-cat competitors. The patentee can either take the patent violators to court or tolerate erosion of its profits. The patentee's decision will depend on net gain from moving to the courts. By going to court, the patentee incurs the time and legal costs, but can restore its profits over the remaining patent life of the product if it is successful. Imitators

[72] Erich Kaufer, *The Economics of the Patent System*, New York: Harwood Academic Publishers, 1989.

[73] For these issues, see Ariel Pakes and Margaret Simpson, "Patent Renewal Data", *Brookings Papers, Microeconomics*, 1989: 331-410; and M. Schankerman, "Measurement of the Value of Patent Rights and Inventive Output Using Patent Renewal Data", *STI Review*, (8), OECD, April 1991: 101-122.

will find it in their interest to increase the litigation costs to the patentee. However, imitators will find it difficult to draw out the legal process for well-defined patented products. Thus, in general, we would expect to see litigation cases for patented products whose scope is open to interpretation.[74]

As technology brings forth new and modified products, the scope of a patent can change. Patents, by their very nature, involve issues and inventions at the leading edge of technology. Most cases involve difficult questions of interpretation of the patent itself, the prior state of the art, and the alleged infringing subject matter. If the patent legislation is imprecise or obsolete, it will breed litigation. The problem arises because there is no consistency in the determination of the scope of the patent. Courts are increasingly having to rely on expert evidence in determining the validity of a patent. The testimony and cross-examination tie up court time, while the losing party can appeal the verdict in the hope that a different interpretation of the expert opinion may be entertained by the next judge. This accounts for escalating litigation costs in patent cases.

On a per capita basis, Canada is an active forum for intellectual property litigation. In Canada, as in the United States, patent litigation is more time consuming than copyright which in turn takes longer to adjudicate than trade-mark disputes. Patent litigation in Canada appears to be particularly slow compared to the United States. To litigate a patent in Canada, it is estimated that it will take over four years following the issuance of a statement of claim before a judgment is rendered by the court. By way of rough comparison, one estimate of the average time in which a case reaching trial before the U.S. District Court will be disposed of is 2.5 years. Patent litigation involves expenses in excess of $1 million in the United States. Of particular concern is the great expense incurred for discovery and the trial itself. In Canada, such costs commonly are in excess of several hundred thousand dollars.[75]

The delays and costs inherent in the litigation of patent rights have led to the search for cost-minimizing alternative dispute resolution mechanisms. There is increased use of arbitration in response to a failure by the courts to deal effectively and efficiently with certain types of patent cases. Advantages of the arbitration mechanism include speed,

---

[74] For a theoretical modelling of these issues, see Michael Waterson, "The Economics of Product Patents", *American Economic Review*, 80, September 1990: 860-69; and Jerry R. Green and Suzanne Scotchmer, "Antitrust Policy, The Breadth of Patent Protection and the Incentives to Develop New Products", Camb. MA: Harvard Institute of Economic Research, Harvard University, Discussion Paper 1467, December 1989.

[75] Gordon F. Henderson, "Intellectual Property: Litigation, Legislation, and Education. A Study of the Canadian Intellectual Property and Litigation System." Consumer and Corporate Affairs Canada, Minister of Supply and Services Canada. 1991.

confidentiality, expertise and flexibility not generally found in the court system. In arbitrations, the parties deal with one arbitrator or one panel of arbitrators throughout the proceedings. By agreeing to arbitrate, the parties also agree that their arbitrator's decision will be final and binding. The arbitration mechanism presents an important opportunity to accomplish a more efficient and better resolution of patent disputes.[76] The value of patents will increase and the benefits for which the patent law was intended can be achieved.

High money and time costs of patent litigation can undermine effective protection that a patent confers. In a situation where a patent is held by a small innovative firm and a large firm attacks the patent, the large firm's infringement may go unchallenged. The small firm may not be able to finance large legal expenses and time delays, whereas the large firm may have deeper pockets. Even if the small firm is able to absorb the litigation costs, it would still face the prolonged uncertainty that can accompany the litigation process. Moreover, the small firm may also be discouraged from engaging in second generation innovations of its existing patent. High patent litigation costs run counter to the objective of the patent system. Therefore, either cost minimizing patent dispute resolution mechanisms, such as arbitration (discussed above), or other cooperative institutional arrangements (such as patent-pooling or patent-swapping) should be explored further to avoid excessive litigation expenses. A reduction in litigation costs will better position small and medium size firms to enforce their patent rights.[77]

[76] John W. Schlicher, "The Patent Arbitration Law: A New Procedure for Resolving Patent Infringement Disputes", *The Arbitration Journal*, 40(4), December 1985: 7-18; and Thomas G. Field, Jr., "Patent Arbitration: Past, Present and Future", *IDEA-The Journal of Law and Technology*, 24(4), Fall 1983: 235-248.

[77] Moreover, for industries where regulatory approval of a patent grant is required, policy makers could usefully explore ways to speed up the regulatory process, thereby increasing the effective commercial life of a given patent, before considering any extension of the existing legal patent term. For instance, in the case of patented medicines, illustrated in the time line chart in Annex C, a reduction in the approval time would increase effective patent protection for both small and large enterprises without entailing any increase in the legal patent term.

VI

CONCLUSIONS

This Paper has discussed the determination of the optimal patent term. The aim of patents is to induce an efficient level of innovation in the economy. The length of a patent is only one instrument that has an impact on innovations. Economic theory and empirical studies point out that the patent term is not particularly central to innovation decisions made by companies trading in international markets. Nevertheless, these companies do patent their innovations. This fact reveals that innovating companies do place some value on obtaining patents.

The value of patents is determined by the exclusivity they provide to capture profits to offset the costs incurred in R&D investments. Profits in competitive markets may be so small that innovators cannot recoup their investment. But innovative products are largely traded in imperfectly competitive markets, where companies earn super-normal profits over the short and medium run. Innovations are an on-going process aimed at securing comparative advantage in the market place. On the basis of comparative advantage, innovative companies make super-normal profits. In part, the super-normal profits reflect a return on a company's R&D investment. But each round of new R&D investment displaces the old product variety. Therefore, in most markets where competition is driven by successive rounds of innovative products, the value of innovations and of patents can be appropriated only over the short to medium run. This means that, no matter what the legal length of the patent, the effective commercial exclusivity period of patents turns out to be not that long in most instances in practice.

Therefore, the conclusion of economic theory, including the new growth theory, that a shorter rather than a longer patent term is optimal in most instances is consistent with what we observe in the market place. Also, innovations generally represent marginal improvements over the existing products and processes, thereby not entailing overly large "sunk" costs. Patenting such products and processes for a shorter rather than a longer exclusivity period makes economic sense. On the other hand, in industries where innovations bring about drastic changes in products and processes, where production costs are consequently reduced substantially, and where large "sunk" costs are required, longer patent terms would be optimal. Thus, in theory, the optimal patent term would vary across industries and countries.

This Paper finds that economic theory and empirical studies suggest that a patent term shorter than the present multilateral norm of 20 years will be efficient. Exceptions include industries, such as chemicals (including the pharmaceutical industry), where a case for a longer patent term is possible.

However, in recent years there has been a growing acceptance, especially among advanced countries, that a common international standard to protect intellectual property is beneficial to growth in trade and investment. Successive rounds of tariff reductions since World War II initially brought about vigorous growth in international trade, but the growth of nontariff barriers in the 1970s and the 1980s partially offset the liberalization of trade that tariff reductions and greater discipline on some non-tariff mechanisms implied. If countries adopt different economy-wide patent terms, as suggested by economic theory, such a policy will increase the chances that countries will misuse the patent policy to create a nontariff barrier for excluding or limiting imports in some industries, or to attract foreign investment. Given that a growing number of countries are planning to adopt the present 20 year term as the patent norm, any temptation to make the patent policy captive to other objectives is surely misplaced. Even though the current 20 year norm may appear to be excessive in many instances, the benefits of ensuring a single standard for a given sector or economy-wide outweigh the costs of varying patent terms among countries.

Taking these factors into account, this Paper argues that, in an integrated world characterized by harmonized patent terms, if one advanced but moderate innovator country, such as Canada, implements a patent policy that differs from the common norm, that country could face retaliation from its major trading partners. Moreover, Canada's failure to follow the international norm in this area would weaken our case that Canada should be viewed as a preferred site for foreign and domestic investments. Given that patents are not central to innovation investment decisions in most industries, it will not be a favourable trade-off for Canada to opt for international pariah status among advanced countries. This would send the wrong signals to potential investors in Canada and lead us to forgo technology inflows in the sectors where patent protection <u>is</u> vital.

How should policy makers respond to suggestions of changes to the current patent system? First, there has to be <u>international consensus</u> on the merits of proposed changes. Second, <u>patent protection should not differ across countries</u>. Provided these two conditions are met, the analysis in this paper would support (a) a shorter rather than a longer patent norm for most industries, and (b) a patent regime that provides for variable patent terms depending on the industry concerned. To arrive at specific numbers for the appropriate patent term in each industry, further cost-benefit work across industries and countries is required.

In addition to patent term, scope of patent protection is also an important trade policy issue and is likely to take on increasing importance in future trade negotiations. The scope of a patent determines how different the competitors' products have to be before they are adjudicated to have infringed the patented product. If a patent is interpreted to provide wide coverage, then unpatented varieties of the product will infringe the patent. Broad coverage deters imitation and preserves a patentee's profits. If the scope is too narrow, the patentee's profits will be whittled away quickly by imitators. Thus, there is a trade-off between the term and the scope of a patent. Because patent coverage is open to interpretations, it has the potential of being abused by some countries either to attract R&D investment or to encourage imitation. This Paper recommends that trade policy analysis and negotiations should take into consideration the scope of patents. It is preferable to nail down the patent coverage upfront in international negotiations to avoid abuse and manipulation for competing industrial policy purposes.

Finally, innovation activity in Canada not only nor even primarily responds to IP rights. Our policies concerning economic growth and investment (especially foreign direct investment), competition, taxation and the development of entrepreneurship are more important. These policies together with industrial IP rights have considerable effect on a country's rate of innovation.

In summary, this Paper argues that as long as our trading partners honor the 20 year norm, it is not in Canada's interest to deviate from that international standard. Deviations from that norm run the risk of being exploited by individual countries and would complicate the multilateral trade environment. Therefore, from the trade policy perspective, this Paper concludes that: (a) *the patent term in Canada has to be consistent with those of its major trading partners;* (b) *Canada should not seek any general extension of the patent term from its current level;* and (c) *any future extension of the patent term should be limited to those industries where the economics of R&D clearly call for such a change.*

ANNEX A

THE NORDHAUS MODEL

A1. The pre-invention product market is competitive.
A2. Invention proceeds under conditions of certainty.
A3. Production in the industry is characterized by constant returns to scale.
A4. B(R) is the amount by which the unit cost of production is reduced by a process invention that is patented by a firm in the industry.
A5. B(R), called the "invention possibility function", is a concave function of R, where R is the number of units of inventive input employed. Also $B'(R) > 0$ and $B''(R) < 0$.

Let the industry face a linear demand function:

$$X(P) = \xi - \eta P \tag{1}$$

Then the pre-invention competitive price equals marginal and average cost of production. If C_0 is the cost per unit of output prior to invention and C_1 is the unit cost after the invention, then it follows that

$$B(R) = \frac{C_0 - C_1}{C_0}. \tag{2}$$

In this model, the maximum royalty which the inventor can charge for licensing all producers in the industry is equal to the total cost savings at the preinvention level of output X_0 given by the area of the rectangle C_0ABC_1, in Figure 1 above. So the inventor's royalty income is $(C_0 - C_1)X_0$ per period during the life of the patent. If C_0 and X_0 are normalized to 1, the royalty income of the inventor will be B(R) per period. After the expiry of the patent, price will decrease to P_1 and the rectangle C_0ABC_1 will be transferred from the inventor to consumers.

A lengthening of the patent term increases the present value of the royalties to the inventor, which in turn increases his incentive to invent. By investing additional resources in inventive activity, larger cost savings can be achieved. The area of rectangle C_0ABC_1 is increased as is the area of the triangle ABD, in Figure 1 above. However, the longer the patent term, the longer consumers have to wait to enjoy this triangle surplus. Thus, the optimal patent term requires a balancing of the loss of current consumers' surplus (which arises from extending the patent term) against the incentives for invention which will result in still larger consumer surplus in the future.

Let the social welfare function be:

$$W = \int_0^{\infty} B(R)\,X_0 e^{\rho t} + \int_T^{\infty} \frac{1}{2}(X_1 - X_0)\,B(R)\,e^{-\rho t}dt - sR \qquad (3)$$

where

X_0 = preinvention level of output, set equal to 1,
$B(R)$ = $(C_0 - C_1)/C_0$ = unit cost saving of investment,
ρ = private and social discount rate,
T = term of the patent, and
s = cost per unit of R.

The first term of the equation (3) corresponds to the area of the rectangle C_0ABC_1 in Figure 1 above, and is the present value of the private benefit to the inventor during the patent period and the benefit to consumer after that. The second term corresponds to the triangle ABD, which is the present value of the additional gain to consumers after the patent expiry. The third term, assuming that all costs are incurred in the first period, is the present value of the cost of R&D.

Since P_0 and C_0 are preinvention price and cost, and $P_0 = C_0$; normalizing $C_0 = 1$, yields $P_0 - P_1 = C_0 - C_1 = B(R)$. From the demand equation $X_0 - X_1 = \eta(P_0 - P_1) = \eta B(R)$, where η is the slope of the demand function, representing the elasticity of demand at $P_0 = X_0 = 1$. When the expression for $X_0 - X_1$ is substituted in equation (3), the integration of equation (2) yields:

$$W = \frac{B}{\rho} + \frac{\eta}{2\rho} B^2(1 - \psi) - sR$$
$$\text{where} \quad \psi = 1 - e^{-\rho T}. \qquad (4)$$

The inventor wants to choose the level of R&D expenditures, R, that maximizes the inventor's return or profit net of costs. The unique inventor has exclusive rights to royalties, B(R), for T periods from his process invention. The net profit maximization calculus then involves a choice of R that maximizes the present value of the royalties minus the resource cost:

$$\Pi = \int_0^T B(R)\,e^{-\rho t}dt - sR$$
$$= \frac{\Psi}{\rho}B - sR.$$

The first order necessary condition is obtained by maximizing (4) with respect to R as follows:

$$\frac{1}{\rho}B'\psi = s. \tag{5}$$

The condition (5) states that the inventor will spend resources up to that level where present value of the income derived from an additional unit of research is equal to its unit cost. To determine the optimal or welfare maximizing patent term one maximizes (3) subject to (5). Differentiating (3) with respect to ψ, noting from equation (5) that

$$\partial R/\partial\psi = B'(R)/B''(R)\psi > 0,$$

we obtain

$$\frac{\partial W}{\partial\psi} = -\frac{B'^2}{\rho B''\psi} - \frac{\eta}{2\rho}\left[\frac{2BB'^2}{B''\psi}(1-\psi) + B^2\right] + s\frac{B'}{B''\psi} = 0. \tag{6}$$

Substituting $\rho s = B'\psi$, equation (5) in equation (2.6), and solving for ψ, one obtains:

$$\psi^*_M = \frac{1+\eta B}{1+\eta B(1+\frac{k}{2})}, \tag{7}$$

where $k = -B''B/B'^2 > 0$ is the degree of concavity of B(R).

Nordhaus calls (5) the inventor's equilibrium and (7) the policy maker's equilibrium. The optimal patent term is the intersection of these two curves. The optimal patent life T is given by

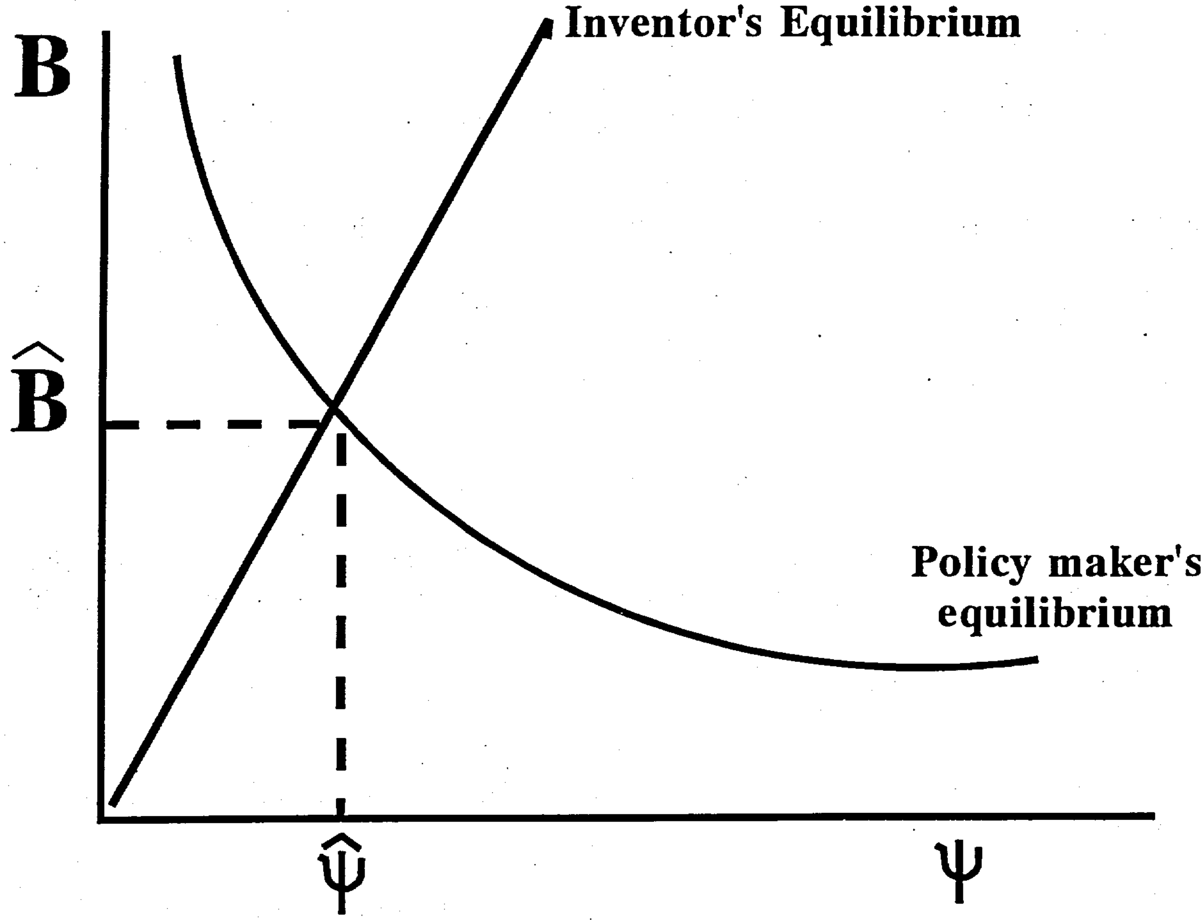
$$T = -\frac{1}{\rho}\ln(1-\psi^*),$$

where T ranges from 0 to ∞ as ψ ranges from 0 to 1 and ψ^* is the optimal value of ψ satisfying equations (5) and (7).

The optimal value of T is determined by the intersection of the inventor's equilibrium (5) and the policy maker's equilibrium (7). Treating ρ and η as parameters, we have two equations to solve for B and T simultaneously. Figure 2 shows the equilibrium for two hypothetical curves.

Figure 2

Optimal Life of a Patent



To give an example, following Nordhaus let us assume

$$B(R) = \beta R^{\alpha}, \tag{8a}$$

where α is the constant elasticity of cost reduction with respect to research. Using (8a) equation (5) becomes

$$R = \left[\frac{\psi\alpha\beta}{\rho s}\right]^{\frac{1}{(1-\alpha)}}. \tag{8b}$$

From equations (8a) and (8b), the size of the invention is:

$$B = \beta\left[\frac{\psi\alpha\beta}{\rho s}\right]^{\frac{\alpha}{(1-\alpha)}}. \tag{8c}$$

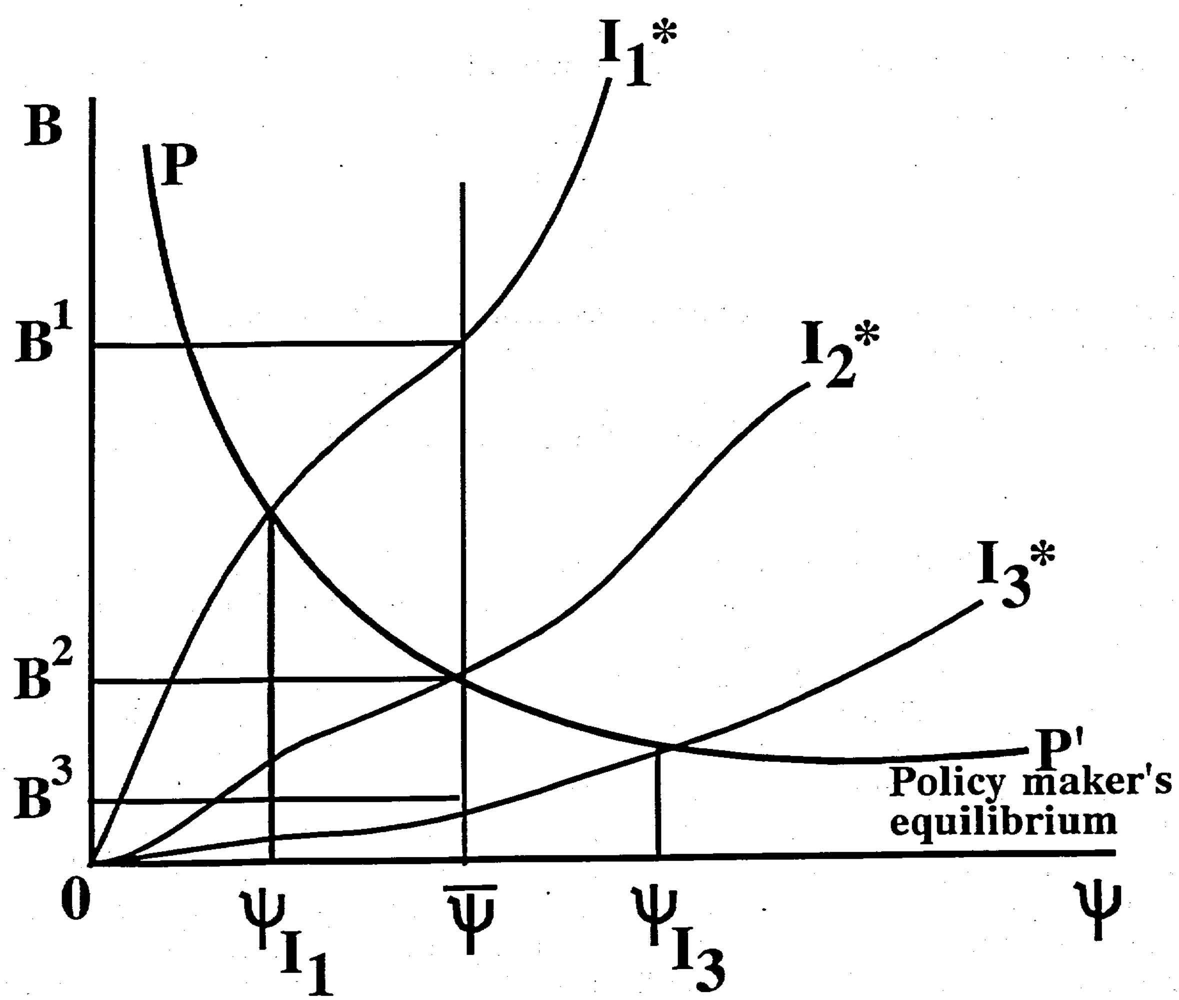
When (8c) is substituted in (7), the optimal patent term ψ^{*} may be obtained from the solution of the equation:

$$\psi + \psi^{\frac{1}{(1-\alpha)}}\left[\eta\beta\left\{\frac{(\beta\alpha)}{\rho s}\right\}^{\frac{\alpha}{(1-\alpha)}}\left(1 + \frac{k}{2}\right)\right] - \psi^{\frac{\alpha}{(1-\alpha)}}\left[\eta\beta\left\{\frac{(\beta\alpha)}{(\rho s)}\right\}^{\frac{\alpha}{(1-\alpha)}}\right] = 1. \tag{8d}$$

It is extremely difficult to solve for ψ from equation (8d). However, it is possible to compute values of T that would satisfy (7) for different values of B and η and determine whether the existing patent term is greater or less than the optimal patent term. The reasoning for this may be illustrated in Figure 3. In Figure 3, PP' represents the solution of the policy maker's equilibrium (7) and represents the existing life of a patent (which is 20 years in Canada and in the United States). The curves OI_1, OI_2 and OI_3 represent inventor equilibria for different industries - I_1, I_2 and I_3. At the existing patent life ψ_0 the observed size of the inventions in the three industries will be B_1, B_2 and B_3. By examining the observed equilibrium points (ψ_0,B_1), (ψ_0,B_2) and (ψ_0,B_3), we can determine whether the existing life is longer or shorter than the optimal. For I_1, I_2 and I_3, the inventor equilibria are respectively to the right of, on and to the left of PP'. Thus, for I_1, the existing life is longer than the optimal; for I_3 the existing life is shorter than the optimal; whereas for I_2, the existing life is optimal.

Figure 3

The Optimal Patent Life for Different Industries



* Inventor equilibrium in Industry

In order to calculate the patent term numerically which would satisfy (7), given Nordhaus' assumptions regarding the demand function of the industry and the invention possibility curve B(R), from equation (7) we can calculate the optimal patent term for given values of α, B, ρ and η. Using $B(R) = \beta R^{\alpha}$ k in equation (7) becomes $k = -B''B/B'^{2} = (1 - \alpha)/\alpha$. We allow B to take an values .005, .01, .1 and η takes on values .5, 1.0, 1.5, 2.0. ρ and α are set at .20 and .1 respectively. The results in Table 1 show that the <u>optimal patent term ranges from 22.5 years to 4.3 years</u>, depending on the amount of cost reduction and the elasticity of demand. As was shown in Figure 2, given the above plausible values of B when the equilibrium T in table 1 (lower left number of each cell) is less than 20 years (which is the existing life of a patent both in Canada and the United States), the optimal patent life is shorter than 20 years. On the contrary, when the equilibrium T is more than 20 years, the optimal life is longer than 20 years.

Table 1

Optimal Patent Terms with Competition and Monopoly in the Invention Industry that Fulfil Policy Maker's Equilibrium, with $\alpha = .10$, and $\rho = .20$.

			η		
		.5	1.0	1.5	2.0
	.005	.5 22.5	.5 19.1	.5 17.2	.5 15.8
B	.01	.5 19.1	.5 15.8	.5 13.9	.5 12.6
	.05	.5 11.6	.5 8.7	.5 7.2	.5 6.2
	.10	.5 8.7	.5 6.2	.5 5.0	.5 4.3

Note: Lower left number in a cell refers to the monopolist inventor, while the upper right cell number pertains the competitive invention industry.

It is interesting to note some comparative static results on the optimal patent term. Table 1 illustrates these results:

(i) The higher the elasticity of demand η, the lower is T, everything else being constant.

(ii) The larger the cost reduction B, the lower is T, everything else being constant.

There are basically two reasons why one might expect a shorter optimal patent life for large cost reductions[78]:

(a) large cost reductions quickly pay for themselves, and
(b) with monopoly pricing, a large cost reduction produces a large deadweight loss.

Therefore optimal social policy should call for an early termination of these deadweight losses. The same arguments apply to the elasticity of demand. The larger the value of η, the larger is the value of the associated deadweight losses. Consequently, the optimal social policy should be a shorter patent life in order to reduce the size of this deadweight loss.

Dore et al. consider a generalized invention possibility function B(R) which exhibits increasing as well as decreasing returns to scale and incorrectly argue that the optimal patent term depends on the variable elasticity of cost reduction with respect to research (output elasticity of research). If a generalized invention possibility function is specified, it can easily be shown that the optimal patent term depends on the variable degree of sharpness (the curvature) of the invention possibility function rather than the output elasticity of research.

[78] F.M. Scherer, 1972, *op. cit.*

ANNEX B

Markets, Output, and Bounties As Determinants Of R&D

1. The Market Structure and R&D

The patent protection confers on an inventor firm monopoly power, which is positively linked to R&D activity. The causality runs from innovation activity to monopoly market structure. To sustain R&D activity, monopoly power is to be accorded to the inventor. Schumpeter-inspired hypotheses, in contrast, suggest that the possession of monopoly power is itself conducive to innovation. That is, an existing monopoly market structure will determine the pace of innovation. As the market structure moves from monopoly to duopoly to looser oligopoly, the ability of firms to hold prices at monopoly levels breaks down. When that happens, the quasi rents per firm will be too small to cover R&D costs not only because the new product market is divided into so many slices, but also because price competition has eroded the market's profitability.

There is a clash between market structure and incentives for innovation. Up to a point, the **stimulus factor** works: increased fragmentation stimulates more rapid and intense support of R&D. But when the number of firms becomes so large that no individual firm can appropriate quasi rents to cover its R&D costs, innovation can be slowed or even brought to a halt.

Historical studies reveal that high concentration in such North American and European industries as synthetic fibers, synthetic rubber, synthetic dyestuffs and derivative organic chemicals, electric lamps, telephone equipment, aircraft engines, and photographic supplies was caused in part by vigorous innovation combined with patent and/or barriers to imitation. Empirically, it is less clear that these tendencies have survived in recent times. The existing evidence favors a conclusion that innovation under late twentieth-century conditions has tended to be more concentration-reducing than the opposite.

In general, larger and diversified firms have a favourable effect on the vigor of R&D efforts. There is statistical evidence that the fraction of total industrial R&D outlays devoted to basic research rises with overall firm size and greater diversification. Vigorous support of basic research, in turn, appears to be positively associated with higher innovative output across individual firms and higher productivity growth across broadly defined industry sectors.

The theory on market structure and R&D suggests that monopoly power is conducive to innovation, particularly when advances in the knowledge base occur slowly. But very high concentration has a positive effect only in rare cases, and more often it is apt to retard progress by restricting the number of independent sources of initiative and by dampening the firms' incentive to gain market position through accelerated R&D. What is needed for rapid technical progress is a subtle blend of competition and monopoly, with more emphasis in general on the former than the latter, and with the role of monopolistic elements diminishing when rich technological opportunities exist.

In sum, the qualitative evidence supports a preliminary conclusion that no single firm size is uniquely conducive to technological progress. There is a place for firms of all sizes. Technical progress thrives best in an environment that nurtures diversity of sizes and that keeps barriers to entry by technologically innovative newcomers low.

2. Output Effect on R&D

An increase in demand for the product normally increases short-run profits, which in turn stimulates R&D activity. That is, the "pull" of demand increases inventive effort. There is evidence that higher R&D activity follows increases in profitability with typically short time lags. Nadiri and Bitros[79] find that in the long run, for five U.S. industries, an increase in output of 1 percent generates a 0.7 percent increase in R&D capital. In Canada, Bernstein[80] estimates the long-run effects to be around unity. In the short run, however, when output increases by 1 percent, the U.S. subsidiaries increase their demand for R&D capital by 0.25 percent, compared with 0.37 percent for the Canadian-owned firms.

Scherer[81] classifies patent data for U.S. manufacturing industries according to the industries of use. He finds a positive, significant relationship between patents by use and the user output. Scherer finds almost a one-to-one relationship between the growth rates of patents and sales. In other words, a 1 percent increase in sales leads to a 1 percent increase in patents.

[79] M.I. Nadiri and G.C. Bitros, "Research and Development Expenditures and Labor Productivity at the Firm Level: A Dynamic Model". In *New Developments in Productivity Measurement*, edited by J.W. Kendrick and B.N. Vaccara. Chicago: National Bureau of Economic Research, 1980.

[80] Jeffery I. Berstein, *Research and Development, Production, Financing and Taxation.* Toronto: University of Toronto Press for the Ontario Economic Council, 1984.

[81] F.M. Scherer, "Inter-industry Technology Flows and Productivity Growth", *Review of Economics and Statistics*, 64, 1982: 627-34.

3. R&D and Factor Prices

R&D capital consists of the output of scientists, engineers, technicians and the activity of commercializing the invention. Physical capital is made up of inputs like equipment, machines, structures and offices. R&D and physical capital tend to be substitutes in the short run but complement each other in the long run, while each type of capital is a substitute for labour. Factor prices affect the cost of physical capital and knowledge capital in a similar way. The capital cost consists of two components: the financing (rate of return) and the utilization of capital (rate of depreciation). The demand for R&D capital is directly affected by the cost of doing R&D. This direct effect is enhanced by the indirect effect on R&D from changes in cost of physical capital. For example, an increase in the rate of return (i.e., financing cost) renders financing capital formation more expensive and thereby dampens the demand for R&D capital.

The demand for R&D capital is three times more responsive to changes in output, compared with changes in its factor price. Thus, in an expanding economy R&D expenditures will increase; and if labour costs increase, the production process will become more capital intensive in terms of both physical and R&D capital.

4. R&D and Tax Incentives

Tax incentives generate positive effects on R&D expenditures. Canada has had a varied and extensive set of tax incentives directed at stimulating R&D capital formation. Although the statutory tax credit in Canada compares favourably with that in other countries[82], the effective tax credit is only slightly above half the statutory rate for the major R&D investors in Canada. This implies that the problem of unutilized tax credits is particularly acute. It is of little value to increase the statutory rate when constraints hinder firms from taking advantage of existing credits.

Bernstein[83] estimates that a doubling of the effective tax credit rate generates a 3 to 6 percent increase in the long-run demand for R&D capital for both U.S. subsidiaries and Canadian-owned firms. In the short run, the effect is about 1.4 percent (1.1 percent substitution and 0.3 percent output effect). Policy initiatives toward R&D investment through tax incentives generally lead to a dollar-for-dollar increase in R&D expenditures. A dollar spent by the government in the form of tax expenditure causes the firm to increase R&D expenditures by one dollar.

---

[82] Donald G. McFetridge and Jacek P. Warda, *Canadian R&D Incentives: Their Adequacy and Impact.* Toronto: Canadian Tax Foundation, 1983.

[83] J.I. Bernstein, 1984, *op. cit.*

5. R&D and Corporate Takeovers

The impact of corporate takeovers or restructuring on R&D can be interpreted taking either the viewpoint of managers or the raiders. The managers' view considers the market myopic: overly concerned with short-term survival at the expense of long-term profitability of the company. When the threat of takeovers increases, as in the 1980s, companies are forced to raise their indebtedness to fend off takeovers. This makes the companies more vulnerable to default if the economy slows down, so the managers cut back on investments in R&D or related areas where the payoffs are long-term rather than short-term. This view concludes that recent changes in the financial strategies of corporations have had an adverse effect on R&D.

The raiders' viewpoint stresses that managers may mis-direct their company's cash flow into investments that do not promise an adequate payoff. Managers want to build their own empires and increase the size of their own companies by investing in R&D even when the technological opportunities are not all that good. It is better for the economy if these funds are paid out to shareholders or bondholders and can then be reallocated to growing and more profitable companies. Corporate restructuring means that a larger share of the company's cash flow will be earmarked for debt service and cannot be used for empire building by managers. The raiders' viewpoint, therefore, also concludes that increases in debt will reduce R&D spending.

Hall[84] examines data on about 2,500 U.S. firms from 1959 to 1987. When a company goes private by means of a leveraged buyout (LBO), there is no major direct effect on R&D investment. She finds that, as a result of mergers, companies performing R&D reduced their R&D intensity (R&D as a proportion of gross output) by about half a percent following an acquisition. This decrease in R&D is not, Hall checks this, a result of the elimination of duplicate R&D after a merger or acquisition. Do companies that shift their financial structure toward greater debt rather than equity reduce their commitment to R&D? Hall reports strong evidence that companies increasing their leverage do reduce their R&D intensity, and this reduction reflects a long-term change. Moreover, the effects can be pronounced: For companies that increase their debt by amounts equal to 50-100 percent of the size of their capital stock (there are 220 such cases in her sample), R&D intensity drops between a quarter and a third.

---

[84] Bronwyn H. Hall, "The Impact of Corporate Restructuring on Industrial Research and Development", *Brookings Papers: Microeconomics*, 1990: 85-135.

6. *R&D and First-Mover Advantage*

First-mover advantages allow the established firms to restrict or prevent competition. One way to gain advantage in the markets for an established firm is to introduce innovative products or processes in its business before its potential rivals move in. An important aspect of "sunk" R&D costs is their commitment value. A firm that incurs large R&D expenses today signals that it will be around tomorrow. Once this commitment is recognized by one's potential rivals, it may have strategic effects. Rivals may interpret the R&D investment as bad news about the profitability of the market and may reduce their scale of entry or not enter at all.

A firm can gain and sustain competitive advantage by achieving lower costs relative to its rivals in the product market. By investing in R&D, the firm can introduce process innovation and remain ahead of the pack. When easy imitation of base technology, such as in pharmaceutical products, decreases the product life cycle, the market share that comes from being first is substantial. Thus, some firms will do R&D even in the absence of the patent regime, possibly to secure a technological lead and an innovator profile in the industry.

There are three important factors in Nordhaus' social welfare maximizing calculus of optimal patent life: (1) the responsiveness of demand to price changes[85]; (2) the "ease" or "difficulty" of achieving cost reducing innovations[86]; and (3) the gains from competitive imitation[87].

The three major conclusions from Nordhaus' model are as follows: First, the greater the responsiveness of demand to price reductions, the shorter the socially optimal patent life. As the demand responsiveness increases[88], the area of the welfare triangle, the area ABD in Figure 1, increases, making society less and less willing to postpone its capture. Second, the "easier" it is to achieve a given cost reduction[89], the shorter the socially

[85] This measure is called the *demand price elasticity*. If a 10 percent decrease in price results in: (a) 10 percent increase in demand, then the elasticity is unity; (b) more than a 10 percent increase in demand, then demand is elastic; (c) less than a 10 percent increase, then it is inelastic.

[86] This depends on the shape or steepness of the invention possibility function (IPF).

[87] This depends on the curvature or sharpness of the IPF

[88] That is, as the demand price elasticity increases.

[89] That is, the steeper is the IPF, reflecting larger cost reductions.

optimal patent life will be. When big cost reductions are likely, whether the allowed patent life is modest or long, society is less willing to postpone the realization of its net welfare surplus to motivate still more cost reduction than it would be if the cost savings under comparable patent life conditions and research investments were modest. Third, the smaller the cost reduction[90] induced by an increase in patent life which reduces society's welfare gain by deferring competitive imitation, the shorter the optimal patent term. Nordhaus finds that, for easy innovations, the socially optimal patent life is shorter than 8 years, whereas for hard innovations even a 20 year patent life is insufficient.

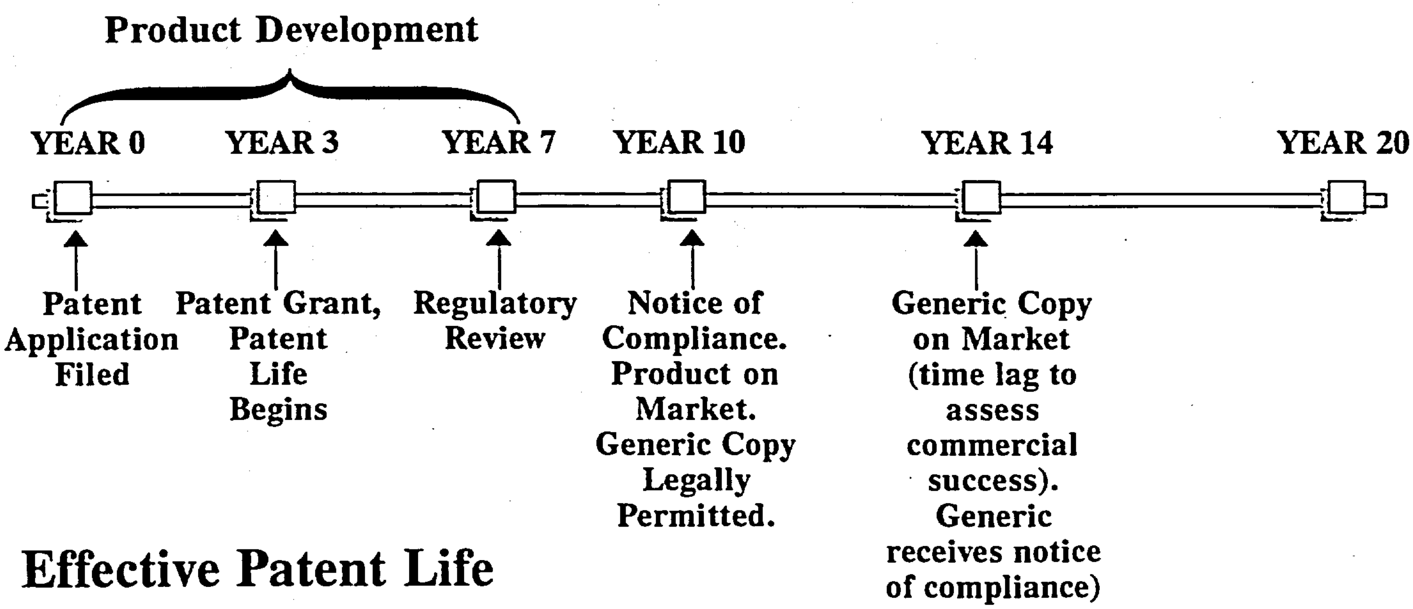
[90] As the IPF takes on sharper curvatures, the amount of cost reduction becomes smaller.

ANNEX C

AVERAGE EFFECTIVE PATENT PROTECTION of PATENTED MEDICINE in CANADA

1) Under the 1969-1987 Law

○ Patent Life and the Marketing of Average Medicine



○ Effective Patent Life

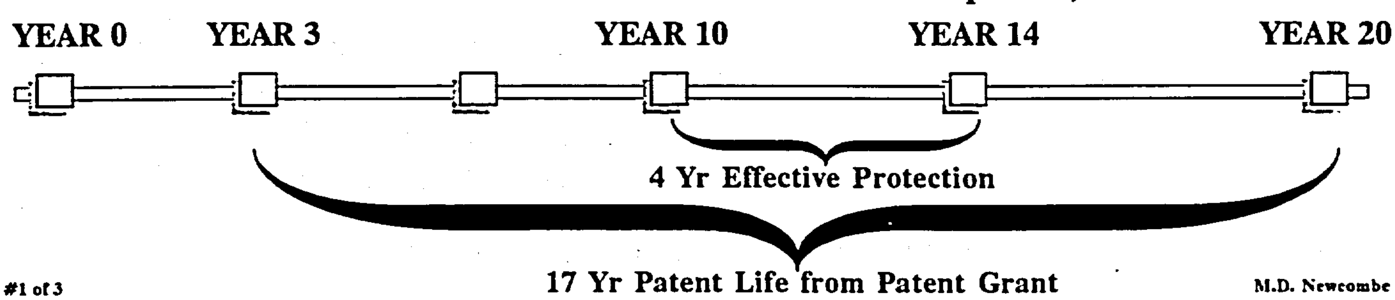


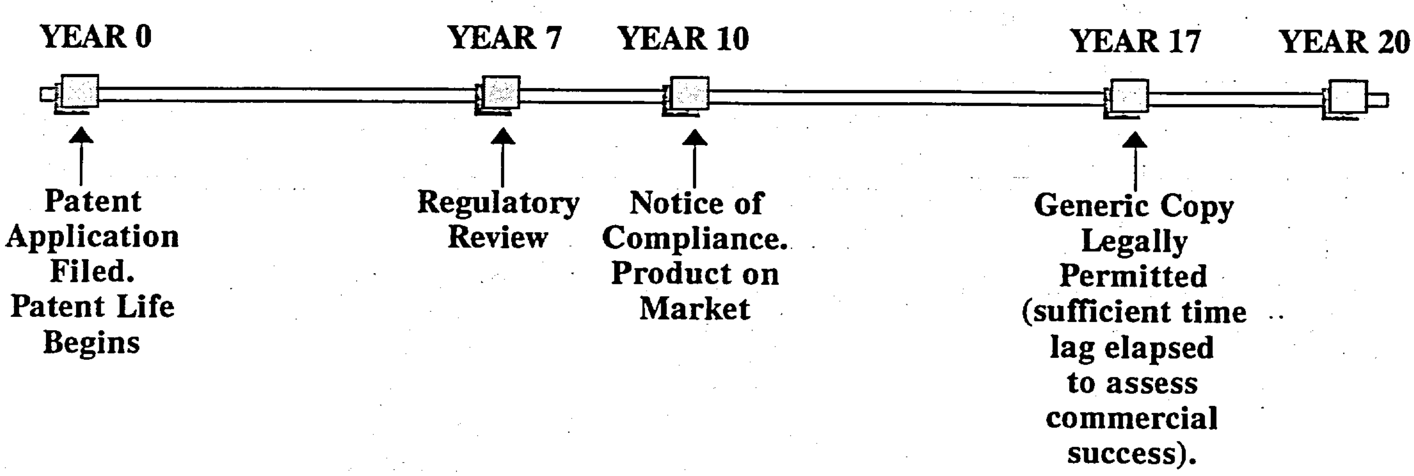
CHART #1 of 3

M.D. Newcombe CPR/93

AVERAGE EFFECTIVE PATENT PROTECTION of PATENTED MEDICINE in CANADA

2) Under the 1987-1992 Law

○ **Patent Life and the Marketing of Average Medicine**



○ **Effective Patent Life**

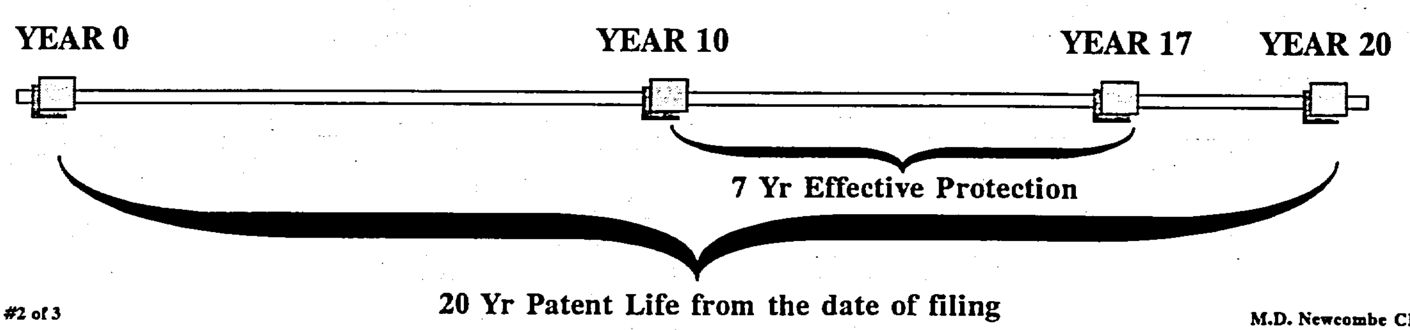


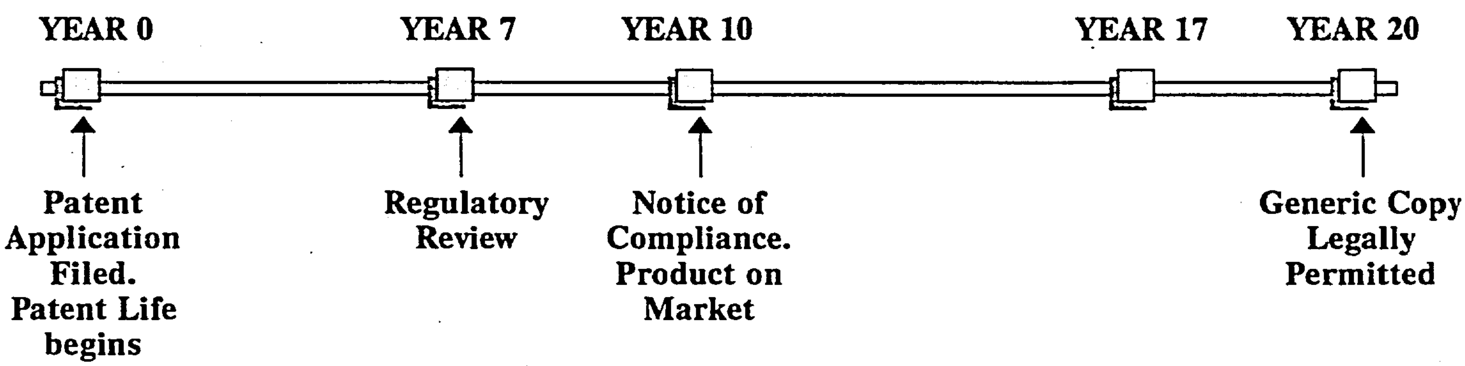
CHART #2 of 3

M.D. Newcombe CPR/93

AVERAGE EFFECTIVE PATENT PROTECTION of PATENTED MEDICINE in CANADA

3) Under the new 1992 Law

○ Patent Life and the Marketing of Average Medicine



○ Effective Patent Life

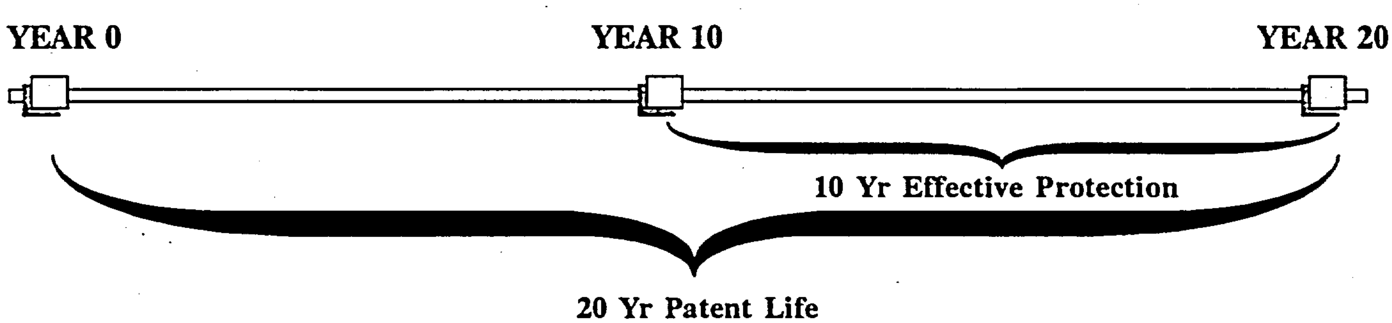


CHART #3 of 3

M.D. Newcombe CPR/93

B) TRADE DEVELOPMENT SERIES

1. From a Trading Nation to a Nation of Traders: Towards a Second Century of Trade Development, by Andrew Griffith. 92/5 (March 1992)

2. Exports and Job Creation, by Morley Martin. 93/6 (June 1993) *

3. Export Financing in an Age of Restraint, by Jamel Khokhar. (forthcoming)

C) REGIONAL TRADE AND ECONOMIC SERIES

1. Different Strokes: Regionalism and Canada's Economic Diplomacy, by Keith H. Christie. 93/8 (May 1993) *

2. Adapting to Change: Canada's Commercial and Economic Interests in Eastern Europe and the Former Soviet Union, by Ann Collins. (forthcoming)

3. International Development Assistance and Bilateral Economic Diplomacy: A Perfect Match?, by Nicolas Dimic. (forthcoming)

4. China 2000: The Nature of Growth and Canada's Economic Interests, by Steve Lavergne. (forthcoming)

D) OTHER ECONOMIC PAPERS

1. World Population Growth and Population Movements: Policy Implications for Canada, by Michael Shenstone. 92/7 (April 1992)

2. Pour des sanctions efficaces et appropriées, par Jean Prévost. 93/4 (mars 1993) *

3. Black Gold: Developments in the World Oil Market and the Implications for Canada, by Sushma Gera. 93/5 (February 1993) *

4. Determinants of Economic Growth in Developing Countries: Evidence and Canadian Policy Implications, by Rick Mueller. (forthcoming)

*** available in English/disponible en français**