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# Independent Inventors and Innovation: An Empirical Study

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# Independent inventors and innovation

## An empirical study

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***Abstract:*** *Independent inventors have generally been overlooked in research on innovation. This study helps fill the knowledge gap. A survey of independent inventors in the USA showed that their inventions tended towards hardware/tool, household products, industrial/commercial products, novelty items and toys/games/hobbies. Thirty-nine per cent of the respondents generated sales from their inventions and approximately 20% profited from them. Inventors who established a company to commercialize their inventions were most likely to achieve sales. However, inventors who licensed their inventions were more likely to achieve higher sales levels than those who commercialized them only via their own company, or by selling their inventions outright.*

***Keywords:*** *independent inventor; invention; innovation; licensing*

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What role do independent inventors play in the innovation process? Surprisingly, a paucity of research has been dedicated to the commercial impact of inventors who accomplish their creative efforts outside institutional contexts. This study of a sample of independent inventors in the USA builds on the limited data from past research and offers new insight into how inventions become innovations. Our goals were to: (1) investigate who these inventors are; (2) measure the level and directions of their inventive activity; (3) analyse how frequently these inventors take their products to market, as well as the manner in which they do so; and (4) test correlations between sales achieved and the routes inventors use to take their ideas to market – outright sale, start-ups and licensing. The findings are of interest to inventors, to companies interested in the role licensing plays in transferring the ideas of independent inventors to the marketplace, and to policy makers concerned with encouraging innovation. The results of this fundamental study also suggest a variety of future research avenues for delving further into the area of independent inventors and innovation.

Below we review the extant research on independent inventors in order to demonstrate the need for fundamental data on their inventive and commercial activities and to provide the basis for our hypotheses on the relationship between sales achieved and routes used to commercialize inventions. The methodology is then presented, and is followed by results, discussion and our conclusions.

### Independent inventors: under-studied and undervalued

Substantial research over the past two decades has been directed towards new product-development processes

and technological innovation in companies and industries (eg Cooper, 1986; Dolan, 1993; Crawford, 1995; Utterback, 1996; and Christensen, 1997). Transfer of technology developed in universities and government labs to the marketplace has been addressed (eg Mansfield, 1995; Jaffe *et al*, 1998). The factors that support innovative regions and nations have also been widely researched. (eg Romer and Griliches, 1993; Porter, 1998). Only a handful of academic studies, however, have focused specifically on the contribution of independent inventors to innovation processes. While Rosenberg (1982) acknowledged the role independent inventors have played historically in technological progress, his interest spanned the wider macroeconomic context of innovation. In his influential book, *The Sources of Innovation*, von Hippel (1998) referred only cursorily to independent inventors, focusing mainly on firms. Burgleman *et al* (2004) alluded to independent inventors in their model of technological innovation, but the role of these 'idiosyncratic tinkerers in a garage' was not detailed.

Anecdotally, it is clear that independent inventors worldwide have made important economic contributions. Wilbur and Orville Wright used proceeds from their bicycle shop to support their exploration of flying. Edwin Armstrong invented FM radio in a basement he rented from Columbia University. Sir Frank Whittle, recognized as the father of modern jet propulsion, supported his early work with private funds. Hugh Le Caine independently pursued his now widely regarded inventions in electronic music and sound generation.

The first patent for an implantable pacemaker was issued in 1962 to independent inventor Wilson Greatbatch. Frampton Ellis invented his athletic shoe, first patented in 1981, using personal savings; Adidas eventually purchased one of his lines. Computer-related innovation has benefited greatly from the efforts of independent inventors. Shumpei Yamazaki's inventions related to semiconductors have netted nearly yen 50 billion in licence fees. Schrage (2003) pointed out that Bill Gates of Microsoft, and Linux originator Linus Torvalds, both began as hobbyists. Spin-offs from the inventive activity of Gates and Torvalds have spurred further economic growth. The personal computer, according to Postrel (1996), 'restored the myth of the garage based tinkerer'. Of the 16 major American inventors personally interviewed by Brown (1988) in *Inventors at Work*, over half spent all or a substantial proportion of their inventive efforts outside of institutional contexts. These inventors included Raymond Kurzweil (artificial intelligence), Jerome Lemelson (industrial robotics) and Stanford Ovshinsky (amorphous semiconductors).

Empirical studies of independent inventors are few and far between. Hisrich (1985) researched the personal characteristics and the commercial and management skills of inventors. Sirilli's (1987) study focused on inventors who had filed patent applications in Italy. Khan and Sokoloff (1993) investigated commercially successful American inventors from 1790 through 1865. Parker, Udell and Blades (1996) studied inventors associated with the Innovation Institute and Inventors Services Program at Southwest Missouri State University. Astebro (1998), noting the striking lack of information on new firm creation by independent inventors, focused his research on the economic significance of start-up activities of Canadian inventors. Dahlin *et al* (2000) studied differences in content between inventions created by independent and corporate inventors.

Why are independent inventors de-emphasized at best or even overlooked? One explanation is that innovation has become the purview of industrial research laboratories, beginning with Edison's lab in Menlo Park in 1876 (Ruttan, 2001). Anderson (2004) noted that 'while independent inventors once were the main source of patents, since the 1930s, corporate labs have been the dominant wellspring of invention'. But he went on to question the effectiveness of these vaunted bastions of innovation, and suggested the behemoths were approaching obsolescence. Munsch (2004) offered a way out by advocating the 'willingness to engage external industrial designers and inventors to partner in the development of new concepts'. Interestingly enough we now seem to be at the same juncture that the late economist Jacob Schmookler faced in the 1950s. In his article, 'Inventors past and present', Schmookler (1957) outlined the prevailing arguments that pointed towards the demise of independent inventors, given the rise of corporate laboratories. However, he believed this view to be 'a serious distortion of reality'. Schmookler's ensuing research demonstrated that 'the contributions of independent inventors continue at an appreciable though reduced volume'. He added, 'while large-scale enterprise unquestionably makes a great contribution to modern technological progress, the claim that it does so alone is entirely unwarranted'.

Patent-activity data from the US Patent and Trademark Office (USPTO) suggest that independent inventors remain active today. USPTO defines an independent inventor as one whose patent at the time of granting is unassigned or assigned to an individual. While not all inventions are protected as intellectual property, patenting data are generally accepted as an indicator of inventive activity. The number of patents awarded to independent inventors increased by an estimated 30% from 1990 through 2000 (Comarow, 2002). USPTO (2002a, 2002b) reported that

independent inventors were granted nearly 30,000 utility patents in 2001, or 18% of all US utility patents.

Independent inventors are generating novel ideas, but are these being commercialized? If so, how? Previous research on commercialization rates and the methods independent inventors use to take their inventions to market is scarce, particularly with regard to licensing. Inventors typically are dissuaded from selling inventions outright, due to relatively low, one-time returns. Astebro (1998) found that start-ups initiated by independent inventors were profitable and survived for as long as other start-ups; however, licensing as an option for commercialization was not addressed. Meanwhile, Parker *et al* (1996) concluded that licensing appeared to be an appealing option for commercialization from the standpoints of both independent inventors and companies that might license inventions; no actual data on the success of this option were provided. Khan and Sokoloff (1993) hinted that licensing was a viable commercialization method. In their study of 160 highly successful inventors in the USA from 1790 through 1865, the researchers noted that taking a product from invention to the market through a start-up company was normally associated with the highest returns. However, their findings indicated that a dual route that included manufacturing and sales, as well as licensing, might have allowed these inventors to capture more returns: '85% of the inventors for whom information is available were directly involved in commercial exploitation of their inventions through manufacture, or both manufacture and licensing'.

In addition to providing much needed basic data on the characteristics and activities of independent inventors, a major goal of our study centred on determining whether achieving sales was correlated with selling inventions outright, starting a company, or licensing inventions to another company. Although Khan and Sokoloff suggest that licensing – in combination – may garner more returns, the prevailing wisdom appears to favour start-ups over licensing. This led to the following hypotheses (hypotheses are stated in the alternative form):

H1a: Inventors who establish their own firms are more likely to achieve sales than those who license or sell their inventions outright.

H1b: Inventors who establish their own firms are more likely to achieve a higher level of sales than those who license or sell their inventions outright.

Testing these hypotheses required that a variety of other variables that might influence the outcome should be controlled. Thus we controlled for the category of invention, whether or not respondents invented full-time or part-time, the number of years they had been inventing, and the level of education they had achieved.

## Methodology

The questionnaire design, survey administration process and the statistical techniques used to analyse the data were as follows.

*Questionnaire design*

An electronic questionnaire was designed using surveypro.com. The questionnaire focused on inventions that had been created and marketed by respondents over the past five years; demographic information requested broader information regarding invention activity as well as other characteristics.

Questions posed to respondents concerned:

- the number of inventions they had developed into a working prototype stage in the past five years;
- the types of inventions created, eg aerospace, electronics, hardware/tools, etc;
- the number of patents awarded to these inventions;
- the number of these inventions taken to the marketplace;
- the manner in which these inventions were taken to the marketplace (outright sale, start-up or licensing);
- the number of these inventions taken to the market that actually generated sales, and the approximate amount of sales generated; and
- the number of these inventions that had generated a profit, and the approximate amount of profit.

Demographic data requested included:

- whether the respondent was a full-time independent inventor, a part-time inventor dependent upon another source of income, an inventor working for another company, or other;
- the approximate number of years respondents had been inventing;
- the number of inventions respondents had developed into working prototypes over their lifetimes;
- current age;
- gender; and
- the highest education level attained.

*Survey universe, sampling and administration*

Independent inventors operate outside institutional contexts, and therefore are very difficult to identify and access. The challenge of isolating a population to study systematically may explain why so little research on independent inventors has been undertaken to date. In order to reach a substantial group of respondents, the

two largest organizations in the USA that focus on independent inventors were contacted and asked to assist in distributing the questionnaire: (1) the United Inventors Association (UIA), and (2) the Inventors' Digest. The UIA and Inventors' Digest each sent out an e-mail to their lists, encouraging independent inventors to participate in the survey, and provided them with the link to the URL associated with the questionnaire. It is important to note that these e-mail distribution lists contained not only independent inventors; members of the lists held various positions related to new product development, including marketing agents, importers, patent attorneys and agents, prototype developers, market researchers and corporate-product scouts. In the questionnaire, respondents were clearly asked to indicate whether or not they were independent inventors (part-time of full-time.) Those who answered 'no' were excluded from the data analysis.

Therefore the sample contained only respondents who were currently independent inventors. In order to ensure that duplicate responses were not used, the IP addresses of all respondents were reviewed. The initial e-mail was sent out in April 2003 and follow-up e-mails were sent out periodically through the end of July 2003.

*Analysis*

Hypotheses were tested using both logit regression analysis and linear multiple regression. The independent and dependent variables used in the analyses are defined in Table 1. To test hypotheses with the logit model, the dependent variable was coded '1' if the inventor reported a positive dollar amount of sales and coded '0' if the inventor reported sales of zero. Inventors who left the sales question blank were dropped from the analysis. We also dropped inventors who indicated that they invented in the context of their employment, rather than in an independent context. To test hypotheses with the regression model, the dependent variable was the natural log of the dollar level of sales reported by each inventor, and the independent variables were those defined in Table 1.[1] Inventors who reported zero as the dollar level of sales, or who failed to report sales at all were dropped from the model, as were inventors who indicated they invented in the context of their employment.[2]

## Results

Data from 351 usable questionnaires from full-time or part-time independent inventors were collected and analysed. The combined e-mail lists included an estimated 10,000 names; thus the overall rate of response was low, at about 4%. However, as noted previously, the e-mail distribution lists of the UIA and Inventors' Digest include a variety of people who are directly and indirectly related to new product development, but who are not independent inventors. The number of responses from the targeted respondents provided adequate data for descriptive analysis and hypothesis testing. Data are provided below on respondent characteristics, their invention activity and commercialization activity. Results of the analyses of correlations between achieving sales and commercialization path are then presented.

*Respondent characteristics*

Table 2 provides data on inventor type, approximate number of years respondents had been inventing, number of inventions respondents had developed into working prototypes over their lifetimes, current age, gender and the highest education level attained.

Most respondents (83%) were part-time inventors; 17% were full-time inventors. The number of years respondents had been inventing ranged from one year or less to 69 years. Fifty-five per cent reported that they had been inventors for 1–10 years; 41% had been inventors for over 10 years. Over half of the respondents (56%) reported that they had developed one to five inventions into working prototypes over their lifetimes; the answer given most frequently was one. However, a dozen respondents reported that they had developed over 50 inventions. The age of respondents ranged from 25 to 86; their mean age was 50.5. Eighty-two per cent of the respondents were male. Over half of the respondents had earned at least an undergraduate college degree.

*Inventive activity of respondents*

Table 3 provides data on the inventive activity of the respondents: the number of inventions they had developed into a working prototype in the past five years and the number of patents they had obtained on these inventions. Table 4 describes the types of inventions developed by the respondents.

When asked how many inventions they had developed into working prototypes within the past five years, 84% answered one or more; the answers ranged from one to 120. The mean response was six; however, the response most frequently given was one invention. The top five invention categories mentioned by respondents were: hardware/tools (23%); household (23%); industrial/commercial (16%); novelty (15%) and toys/games/hobbies (15%). Categories mentioned least frequently were closely related to science and technology: marine/ocean technology (3%); telecommunications (3%); biological/microbiological (2%); and mineral recovery/processing (2%). However, science/technology-based inventions in the areas of electronics (13% of

**Table 1. Variable definitions for models.**

| Independent variables | Definition |
|---|---|
| Own company | Coded 1 if inventor marketed inventions through his or her own firm, zero otherwise. |
| License | Coded 1 if inventor licensed inventions to others, zero otherwise. |
| Sell | Coded 1 if inventor sold the rights to inventions to others, zero otherwise. |
| Sciencetech | Coded 1 if inventions are related to science or technology, zero otherwise. This category includes aerospace, biological, electronics, energy generation/utilization, environmental control, marine technology, medical, mineral recovery/processing, telecommunications and transportation. |
| Household | Coded 1 if inventions are related to household products, zero otherwise. This category includes electrical/lighting, food, hardware, household, kitchen/bath, lawn/garden and safety/security. |
| Personal | Coded 1 if inventions are related to personal products, zero otherwise. This category includes apparel, health/beauty, infant/children, sports/fitness/recreation and toys/games/hobbies. |
| Commercial | Coded 1 if inventions are related to commercial products, zero otherwise. This category includes arts/crafts/graphics, automotive, industrial/commercial, manufacturing technology, novelty, office supplies/stationery and restaurant/hospitality. |
| Agriculture | Coded 1 if inventions are related to agricultural products, zero otherwise. This category includes agricultural/livestock and animal care/pets. |
| Full-time | Coded 1 if inventor was a full-time inventor, zero otherwise. |
| Years | A continuous variable representing the number of years the inventor has been inventing. |
| College | Coded 1 if inventor earned at least a bachelor's degree, zero otherwise. |
| **Dependent variables** | |
| Sales (Model 1) | Coded 1 if the inventor reported a dollar amount of sales greater than zero, zero otherwise. |
| LnSales (Model 2) | The natural log of the dollar amount of sales reported by the inventor. |

**Table 2. Respondent demographics (n = 351).**

| Variable | Values | No of respondents | % | Mean* | Median* | Mode* |
|---|---|---|---|---|---|---|
| *Type of inventor* | Full-time independent inventor | 61 | 17 | | | |
| | Part-time independent inventor dependent on another source of income | 290 | 83 | | | |
| *Number of years as an inventor* | <1 | 6 | 2 | 13.5 | 10 | 10 |
| | 1–5 | 113 | 32 | | | |
| | 6–10 | 81 | 23 | | | |
| | 11–25 | 95 | 27 | | | |
| | >25 | 45 | 13 | | | |
| | No answer | 11 | 3 | | | |
| *Number of inventions developed into a working prototype stage over lifetime* | 0 | 24 | 7 | 13.8 | 4 | 1 |
| | 1–5 | 195 | 56 | | | |
| | 6–10 | 49 | 14 | | | |
| | 11–50 | 66 | 19 | | | |
| | 51–100 | 6 | 2 | | | |
| | >100 | 6 | 2 | | | |
| | No answer | 5 | 1 | | | |
| *Age* | 25–30 | 11 | 3 | 50.5 | 49 | 40 |
| | 31–40 | 76 | 22 | | | |
| | 41–50 | 99 | 28 | | | |
| | 51–60 | 89 | 25 | | | |
| | 61–70 | 46 | 13 | | | |
| | >70 | 27 | 8 | | | |
| | No answer | 3 | 1 | | | |
| *Gender* | Female | 59 | 17 | | | |
| | Male | 288 | 82 | | | |
| | No answer | 4 | 1 | | | |
| *Highest educational level* | High school | 87 | 25 | | | |
| | Undergraduate college degree | 146 | 42 | | | |
| | Master's degree | 47 | 13 | | | |
| | PhD | 5 | 1 | | | |
| | Law degree | 2 | 1 | | | |
| | MD | 10 | 3 | | | |
| | Other | 54 | 15 | | | |

***** Mean, median and mode calculations exclude respondents who answered '0' or provided no answer.

**Table 3. Respondent inventive activity over past five years (n = 351).**

| Variable | Values | No of respondents | % | Mean* | Median* | Mode* |
|---|---|---|---|---|---|---|
| *The number of inventions respondents had developed into a working prototype stage in the past five years* | 0 | 23 | 6 | 5.6 | 2 | 1 |
| | 1–5 | 252 | 72 | | | |
| | >5 | 60 | 17 | | | |
| | No answer | 16 | 5 | | | |
| *The number of patents awarded to these inventions* | 0 | 150 | 43 | 2.8 | 1 | 1 |
| | 1–5 | 172 | 50 | | | |
| | >5 | 10 | 3 | | | |
| | Patent pending | 12 | 3 | | | |
| | No answer | 7 | 2 | | | |

**Table 4. Types of inventions created by respondents (respondents could provide more than one answer); n = 351.**

| Invention type | No of respondents | Percentage |
|---|---|---|
| Hardware/tools | 80 | 23 |
| Household | 79 | 23 |
| Industrial/commercial | 55 | 16 |
| Novelty | 52 | 15 |
| Toys/games/hobbies | 53 | 15 |
| Sports/fitness/recreation | 52 | 15 |
| Automotive | 49 | 14 |
| Electronics | 47 | 13 |
| Safety/security | 46 | 13 |
| Medical/therapeutic | 43 | 12 |
| Animal care/pets | 39 | 11 |
| Lawn/garden | 39 | 11 |
| Kitchen/bath | 38 | 11 |
| Electrical/lighting | 35 | 10 |
| Apparel/accessories | 33 | 9 |
| Arts/crafts/graphics | 32 | 9 |
| Health/beauty | 31 | 9 |
| Energy generation/utilization | 30 | 9 |
| Food/beverage | 25 | 7 |
| Office supplies/stationery | 26 | 7 |
| Infant/children | 26 | 7 |
| Manufacturing technology | 24 | 7 |
| Aerospace | 19 | 5 |
| Environmental control | 18 | 5 |
| Transportation | 15 | 4 |
| Agriculture/livestock | 14 | 4 |
| Restaurant/hospitality | 13 | 4 |
| Telecommunications | 12 | 3 |
| Marine/ocean technology | 9 | 3 |
| Biological/microbiological | 6 | 2 |
| Mineral recovery/processing | 6 | 2 |
| Other | 58 | 17 |

respondents) and medical/therapeutic (12%) were more frequent. Over half of the respondents (52%) had been awarded at least one patent for inventions developed over the past five years; 43% had no patents.

*Commercialization activity of respondents*

Table 5 describes the commercialization activities of the respondents: the number of inventions developed over the past five years that they had tried to take to the marketplace; whether or not they had realized sales and profits from their inventions and, if so, how much, and the manner in which they had tried to commercialize these inventions.

Seventy-three per cent had tried to take at least one of the inventions they had developed over the past five years to the marketplace. Thirty-nine per cent of all respondents had generated sales from their inventions; and 22% of all respondents had profited from their inventions. Although the mean number of inventions taken to the marketplace was four, the median and mode were both one. Two per cent of the respondents had attempted to market over 20 inventions. Of the 257 respondents who had tried to take at least one invention to market, 53% had generated sales from their inventions. Thirty per cent of the 257 respondents who had taken a product to the marketplace had generated a profit. Of the 137 respondents who had generated sales, then, 57% had generated a profit. Sales ranged from $13 to $115 million: while the mean sales level was $3.5 million, the median was $50,000 and the mode was $5,000. Profits ranged from $1 to $55 million. While profits averaged $1.96 million, the median was $75,000 and the mode was $100,000.

Respondents were asked to indicate which way or ways they had tried to commercialize their inventions. Results are presented in Table 6. Fifty-five per cent had commercialized their inventions through a company they started in which they either: (1) outsourced manufacturing of the product but distributed it (29%); or (2) manufactured the product and also distributed it (26%). Forty-four per cent licensed the rights to their product to another company; and 16% sold their inventions outright.

*Correlation between sales and commercialization route*

Results of hypothesis testing regarding whether method of commercialization was correlated with achievement of sales, using the logit model, are presented in Table 7.

**Table 5. Respondent commercialization activity (n = 351).**

| Variable | Values | Number of respondents | % | Mean* | Median* | Mode* |
|---|---|---|---|---|---|---|
| *The number of inventions respondents tried to take to the marketplace* | 0 | 85 | 24 | 4 | 1 | 1 |
| | 1–5 | 235 | 67 | | | |
| | 6–20 | 14 | 4 | | | |
| | >20 | 8 | 2 | | | |
| | No answer | 9 | 3 | | | |
| *The number of inventions taken to the market that actually generated sales* | 0 | 146 | 42 | 3.9 | 1 | 1 |
| | 1–5 | 125 | 36 | | | |
| | >5 | 12 | 3 | | | |
| | No answer | 68 | 19 | | | |
| *How much in terms of sales did these inventions generate?* | 0 | 138 | 39 | $3.5 million | $50,000 | $5,000 |
| | 1–10,000 | 45 | 13 | | | |
| | 10,000–100,000 | 27 | 8 | | | |
| | 100,000–1 million | 22 | 6 | | | |
| | >1 million | 25 | 7 | | | |
| | No answer | 94 | 27 | | | |
| *The number of inventions that had generated a profit* | 0 | 193 | 55 | 29.5 | 1 | 1 |
| | 1–5 | 71 | 20 | | | |
| | >5 | 7 | 2 | | | |
| | No answer | 80 | 23 | | | |
| *How much in profits?* | 0 | 177 | 50 | $1.96 million | $75,000 | $100,000 |
| | 1–10,000 | 15 | 4 | | | |
| | 10,000–100,000 | 21 | 6 | | | |
| | 100,000–1 million | 11 | 3 | | | |
| | >1 million | 12 | 3 | | | |
| | No answer | 115 | 33 | | | |

* Mean, median and mode calculations exclude respondents who answered '0' or provided no answer.

**Table 6. Ways in which inventions were taken to the marketplace (respondents could indicate more than one path used); n = 351.**

| Commercialization path | No of respondents | Percentage |
|---|---|---|
| Started through a company inventor, which both manufactures and distributes | 93 | 26 |
| Started through a company inventor, which distributes, but which outsources manufacturing | 103 | 29 |
| Through licensing to another company | 153 | 44 |
| Through selling the invention outright to another company | 56 | 16 |
| No attempt has been made to market inventions | 55 | 16 |
| Other | 48 | 14 |

The final sample consisted of 115 independent inventors who reported sales greater than zero, and 134 reporting sales equal to zero.

Overall, the results for Model 1 were significant as indicated by the chi-square statistic, and explained 58.2% of the variation in the dependent variable as indicated by the likelihood ratio index.[3] The results of Model 1 suggest that achieving sales was significantly correlated with whether the inventor established his or her own company to commercialize the invention ($p<0.0001$),[4] thus supporting H1a. Moreover, this significant relationship held true regardless of type of invention developed, the full- or part-time status of respondents, or the level of education they had attained.[5]

Results of hypothesis testing as to whether method of commercialization was correlated with the level of sales, using a multiple regression model, are provided in Table 8. The final sample consisted of 115 independent inventors who reported dollar sales greater than zero.

The results of Model 2 suggest that the licensing method of commercialization was significantly and positively associated with the level of sales. That is, inventors who chose to license their inventions to others were more likely to achieve a higher *level* of sales than those who only sold their inventions outright, or commercialized them via their own company.[6] Thus H1b is *not* supported. This held true regardless of type of invention developed, full- or part-time status of respondents, or the level of education they had attained.[7]

**Table 7. Results of Model 1: logit analysis of sales.**

| Independent variable | Parameter estimate | Chi-square | *p* value |
|---|---|---|---|
| Intercept | –2.148 | 16.542 | 0.0001 |
| Own company | 3.397 | 64.660 | 0.0001 |
| Sciencetech | –1.193 | 8.754 | 0.0031 |
| Household | –0.685 | 3.507 | 0.0611 |
| Personal | –0.323 | 0.740 | 0.3897 |
| Commercial | –0.026 | 0.005 | 0.9450 |
| Agriculture | 0.263 | 0.238 | 0.6254 |
| Full-time | 2.651 | 25.210 | 0.0001 |
| Years | 0.026 | 2.833 | 0.0923 |
| College | 0.174 | 0.221 | 0.6380 |

Likelihood ratio chi-square = 143.7307 (df = 9)
Likelihood ratio index[3] = 0.582

*Notes:* *p* value <0.0001; n = 115 inventors reporting sales >0, and 134 reporting sales = 0.

**Table 8. Results of Model 2: multiple regression analysis of Lnsales (n = 115).**

| Independent variable | Parameter estimate | *t* value | *p* value |
|---|---|---|---|
| Intercept | –5.008 | –7.24 | 0.0001 |
| License | 1.186 | 2.11 | 0.0370 |
| Sciencetech | –0.052 | –0.09 | 0.9312 |
| Household | –1.115 | –2.07 | 0.0407 |
| Personal | –0.466 | –0.86 | 0.3894 |
| Commercial | –0.770 | –1.41 | 0.1617 |
| Agriculture | 1.017 | 1.41 | 0.1618 |
| Full-time | 3.412 | 6.10 | 0.0001 |
| Years | 0.071 | 2.81 | 0.0060 |
| College | 0.132 | 0.24 | 0.8112 |

F value = 7.93 (df = 9) R-square = 0.407
*p* value <0.0001 Adjusted R-square = 0.3557

## Discussion

Below findings are discussed regarding the characteristics of the respondents, their inventive activity and commercialization efforts.

*Characteristics of the respondents*

The average respondent in the study sample was a part-time inventor; 50 years old and male; and had at least an undergraduate degree. This demographic pattern of respondents generally mirrors those of previous studies. In Hisrich (1985) the age of inventors ranged from 30 to 71, and they had college and even postgraduate degrees. In Sirilli's (1987) study of Italian inventors the average age was 46.5; and more than 75% held a diploma or university degree. Part-time inventors also predominated in Sirilli's study: only one-third said their main activity was as an inventor. Parker *et al* (1996) studied a sample of inventors from files of the Innovation Institute and Inventors Services Program at Southwest Missouri State University: 81% of the respondents were male; and 68% had received at least some college training. The majority of inventors in the sample were between 30 and 49 years old. Eighty-nine per cent of the Canadian inventors studied by Astebro (1998) were male. The predominance of male inventors is also consistent with a recent article in *Scientific American* (2002), which reported that, from 1970 through 1895, about 1% of patents issued to US inventors included the name of a woman; however, by 1998, 10.3% of patents issued to US inventors included the name of a woman.

*Inventive activity over the previous five years*

Most respondents in our study sample had developed their inventions over the past five years into working prototypes. Although the rate of invention varied widely in the sample, on average the inventors had developed six inventions into working prototypes. The median of two and mode of one suggested that most inventors were less prolific. The inventions developed by respondents were related mainly to hardware/tool, household products, industrial/commercial products, novelty items and toys/games/hobbies. Only a few respondents developed inventions related to marine/ocean technology, telecommunications, biological/microbiological and mineral recovery/processing. However, science/technology-based inventions related to electronics and medical therapeutic products were more prevalent.

This emphasis of inventive activity is consistent with that of previous studies. Astebro (1998) suggested that independent inventors tended to contribute inventions that were relatively technically simple and less expensive to develop. In his study, 47% of the inventions were consumer-oriented; 6% were in high technology and 6% were related to industrial equipment. Although Comarow (2002) noted contributions of independent inventors even in high-technology fields, in their study of inventions related to tennis rackets, Dahlin *et al* (2000) found that independent inventors held fewer patents in complex technologies than inventors in corporate contexts.

*Commercialization activity over the previous five years*

Nearly three-quarters of all the respondents had tried to take one or more of the inventions they had developed over the past five years to the marketplace. About four out of 10 of all respondents had generated sales from one or more of their inventions, and about one in five had profited from this. Of those respondents who had tried to take their product to market, about half generated sales, and one in three generated a profit.

The rate at which inventors took their products to market in our research greatly exceeded that reported in Astebro's study (1998), in which the commercialization rate of inventions brought to the market by new firms started by independent inventors was very low (6.5%). Given that Astebro reported the sales and gross profit levels associated with inventions, it is probably best to compare his 6.5% figure with the 39% figure in the study sample, as the latter referred to the proportion of all respondents who actually generated sales (73% of the respondents in our study indicated that they had tried to take their product to market, but had not necessarily realized sales). The mean in our study was $3.5 million, which exceeds Astebro's $187,875 by over a magnitude. The mode in the study sample was $5,000, *versus* 0 to $3,650 in Astebro; the median in the study sample was $50,000, *versus* $3,650 to $18,250 in Astebro. (While inflation over the period between 1995, when Astebro's survey was administered, and 2003 narrows the difference between the figures in the two studies, a marked difference remains.)

What might explain the difference in commercialization rates in these two studies? The universe from which the sample was taken provides some insight. The universe in Astebro's study included only independent inventors who had received invention evaluation assistance from the Canadian Industrial Innovation center in Waterloo. In his study, Hisrich (1985) found that the least successful inventors showed a 'greater perceived need for invention evaluation assistance'. Thus a lower rate of success in taking their inventions to the marketplace would be expected from a sample of inventors who had received this sort of assistance. The universe of our study included a range of inventors – from novices to very experienced – and our sample demographics reflected this. The average respondent in our sample had been inventing for 1 to 10 years. Although on average they had developed 1 to 5 inventions into a working prototype over their lifetime, 37% of the respondents had developed over 10 inventions to the working-prototype stage. Thus we were not surprised that the commercial activity of our sample exceeded that of Astebro. Moreover, in their study Dahlin *et al* (2000) noted that Astebro's study concerned all inventions, not necessarily patented ones. They argued that patenting serves as a screen: that once they are patented, inventions have a higher chance of commercial success. Astebro did not indicate the degree of patent activity in his sample. However, 52% of the respondents in our study had obtained patents for their inventions. Finally, Astebro focused on sales achieved by independent inventors who had started firms around their inventions. Our study also included generating sales from licensing and outright sale of inventions.

*Commercialization methods correlated with sales*

The logit model suggested that inventors who achieved sales tended to do so when they established their own company to commercialize the invention. Achieving sales was not significantly related to the commercialization paths of licensing or selling inventions outright. However, the results of the multiple regression model suggested that inventors who chose to license their inventions to others were more likely to achieve a higher *level of sales* than those who only sold the rights to their inventions, or commercialized them via their own company. Khan and Sokoloff's (1993) findings, as well as findings from our study, indicate that inventors who want to increase their chances of success, as measured by sales, should seriously consider licensing their inventions as a viable commercial path. Even if they also start a company around an invention, licensing augments sales generated by the start-up. For inventors who do not have the desire, capability or resources to start a company, licensing offers a lower-cost and lower-risk option. Success implies that independent inventors will need to climb the learning curve of licensing. Fortunately, a substantial body of trade literature, as well as a cottage industry in consultancy, have emerged to assist independent inventors in licensing their inventions to established manufacturers (see, for example, Reese, 2002; UIA, 2002). The Internet also boasts a variety of online services directed towards licensing inventions.

Licensing not only benefits independent inventors, but established companies as well. Parker *et al* (1996) noted that the high cost of internal R&D had encouraged companies to turn to independent inventors. Moreover, companies who intentionally or unintentionally find that their internal R&D efforts are limited to line extensions and marketing can gain access to the breakthrough ideas created by inventors who are not confined to the corporate context. More recently, Quinn (2000) highlighted the wisdom of outsourcing innovation. Rigby and Zook (2002) also argued for taking an 'open market' approach to innovation, which includes actively seeking inventions from external sources.

## Summary, research limitations and future research

The findings from our study show that independent inventors are active in inventing, and also take their ideas to market. Nearly 40% of the respondents had generated sales from their inventions, and about 20% of all respondents had profited from them.

Moreover, it appears that inventors and companies should give more consideration to licensing as a viable route for commercializing inventions. Inventors who establish their own company to commercialize their

inventions are most likely to achieve sales; however, inventors who license their inventions to others are more likely to achieve a higher *level of sales* than those who sell the rights to their inventions, or commercialize them only via their own company. The licensing option benefits the inventor who prefers to operate outside institutional contexts, while simultaneously providing established companies with access to breakthrough ideas.

This study has the usual limitations that apply to non-experimental research methods. First, and most importantly, the study uses self-reported survey data that, by nature, are subject to respondent error. To the extent that survey respondents failed to understand the questions, had poor memories, or engaged in intentional deception, our findings are limited. Although inherently limited, we used the survey method because it provided us with a large sample of data that were not directly observable. There is no publicly available database that contains all the variables of interest to this study. The possibility of respondent error may be particularly relevant to variables related to the dollar amount of sales reported by respondents. To the extent that success is measured in sales, respondents may be inclined to report a higher level of sales than was actually achieved. We chose to mitigate the effects of this type of error by using the logit method in addition to regression analysis.

Second, the survey method and the logit and regression methods are descriptive, not explanatory. As such, the methods cannot offer any insights into cause-and-effect relationships. Although regression analysis and logit analysis can indicate a relationship between two variables, without underlying theory, neither method proves causation. We used these methods to determine whether a relationship existed as a first step towards developing a theory.

Finally, a lack of significance in the regression and logit models does not necessarily mean that there is no relationship between non-significant variables and the inventors' success as measured by sales. Instead, the lack of significance may be attributable to respondent and other non-sampling errors inherent in the survey method. Further study may provide insight on whether other relationships are significant to achieving sales and to the level of sales.

Our study points towards the value of additional research on the commercialization activity of independent inventors. For example, although most of the inventors focused on lower-technology products, the fields of electronics and medical therapeutics were on their radar screen: the specific types of inventions being pursued and commercialized in these fields warrant further investigation. The licensing option also deserves study. Can licensing alone be used successfully, or is the dual approach of starting a company and licensing necessary? What contributes to a successful licensing strategy from the standpoint of the inventor? Are companies in certain industries more accepting than others towards accessing ideas from independent inventors? How important are inventors in the R&D strategies of companies at present? How important *should* they be? What policy changes might encourage additional commercialization activity on the part of independent inventors and/or beneficial relationships between independent inventors and companies in need of novel ideas? Our study focused on independent inventors in the USA. Understanding the role of independent inventors in innovation demands that this research scope should be widened to include the contributions of independent inventors worldwide, and not only in industrialized countries. For example, technological progress in India, China, South Korea and many Latin American countries favours invention, some of which may be occurring outside institutional contexts.

Like Schmookler in the 1950s, we believe independent inventors in the twenty-first century deserve increased attention from researchers, companies that may benefit from licensing, and policy makers. While isolating the contributions of individual inventors from the broader context of innovation is admittedly challenging, finding ways to do so is imperative.

If Anderson's (2004) insight into the looming shortfalls in innovation of large corporate laboratories comes to pass even in part, overlooking the existing and potential contributions of independent inventors will surely be a costly mistake.

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## Notes

[1] The natural log transformation of sales was used to produce a normal distribution for the dependent variable.
[2] Analyses using profit as a dependent variable were not performed due to the likelihood that respondents would employ widely differing definitions of profit; sales were deemed to constitute a more reliable measure in this study.
[3] The likelihood ratio index is defined in Judge *et al* (1988).
[4] We also used models that included the License and Sell variables, but found no significant relationship between these variables and the likelihood of achieving sales.
[5] We also used models that incorporated an independent variable for gender, and additional variables representing advanced college degrees and professional degrees, but found

no significant relationship between these additional inventor characteristics and the likelihood of achieving sales.

[6] Additional models using Sell and Own Company as independent variables were run, and neither was found to be significantly correlated with the dollar level of sales.

[7] As with Model 1, models that incorporated an independent variable for gender were also used, and additional variables representing advanced college degrees and professional degrees; no significant relationship was found between these additional inventor characteristics and the level of sales.

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