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Productivity Profiles of Korean Inventors: A First Look at the Korean Inventor Panel Data*

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Albeit numerous endeavors in matching names and surveying inventors, inventor-level studies of patent data have been scarce because unique inventors can not be identified across patents. Using the Korean patent data with inventor IDs, birth year, and gender available, we construct unique inventor-level panel data. As the first undertaking with our data, we investigate the age profile of patent productivity among inventors. We find an inverted U-shaped profile with the peak at age 31. We also find an increasing productivity for younger cohorts of inventors. These findings are robust after we control for the calendar year effects and the quality of patents.

Keywords: patent, inventor, productivity, age profile, cohort effects

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I. Introduction

Studies using patent data from the intellectual property offices around the world have surged in the past few decades. This development is mainly due to three factors. First, an interest in technological advances has been heightened among academic researchers since the Information and Communications Technology (ICT) revolution because technological progress is well acknowledged as the most important driver of firm growth and rising standard of living in modern economies.

Second, patents have become a de facto vehicle for intellectual property protection and the data on patent filings now include most significant advances of technology in many fast-growing industries such as pharmaceutical, semiconductor, and nanotechnology industries. Third, as more computing power has become available to handle large databases, a rising number of studies have been conducted with patent data.

At the earlier stage of the line of research using patent data, most studies investigated issues at the firm level by merging firm information from databases such as Compustat with patent data. Since patent documents include information on assignees who have the ownership of inventions on the patents, they were able to merge the two databases by matching assignee names on patent documents to firm names on industry databases.[1)]

Important pieces of information on patent documents which have not been extensively utilized so far in the literature pertains to inventors of patented technologies who are listed on each patent. The reason for the scarcity of research on inventors is quite clear: we can not identify unique inventors across multiple patents since they are not assigned unique identification numbers, and it is extremely challenging to identify the same inventor on different patents with same or similar names. For example,

[1)] Classical research questions in this regard include the relationship between firm size and innovation (Schumpeter, 1943; Acs and Audretsch, 1991; Cohen and Klepper, 1996) and the impact of product market competition on innovation (Scherer, 1967; Nickell, 1996; Aghion et al., 2005).

among numerous patents with an inventor named John Smith, it is not easy to see which patents belong to which John Smith.

However, the last decade has witnessed two major methodologies employed in the literature in order to retrieve inventor-level panel data from patent records. The first method pertains to matching inventor names across patents, or disambiguation of inventors' names. However, matching inventors solely by their names can not be effective because (1) names can be abbreviated from the full name, and (2) middle names can be shown with an initial, full middle name, or blank, and (3) foreign names are susceptible to different phonetic interpretations (Lai, D'Amour, and Fleming, 2009).

For better matching outcomes, all studies that employed this method utilized information on patent documents beyond inventor names, including inventors’ addresses, assignee names (which are typically the names of the firms), co-inventor names, patent classes, and citations (Trajtenberg, Shiff, and Melamed, 2006; Lai, D'Amour, and Fleming, 2009; Kim, Lee, and Marschke, 2009).

A critical problem of this disambiguation method is its accuracy because the method relies solely on the information provided by a patent document. On the one hand, we may have an under-matching error (that is, a Type I error) of not assigning patents to proper inventors, which can occur more likely to prolific inventors. On the other hand, there may be an over-matching error (that is, a Type II error) of assigning patents to wrong inventors or identifying distinct inventors as the same person, which can take place more likely for popular names (the “John Smith” problem).

The second method for the construction of inventor-level panel data has to do with inventor surveys. The efforts in this endeavor have produced datasets such as PatVal-EU I and II (based on surveys of inventors mostly from European countries), PatVal-JP (based on surveys of Japanese inventors), and PatVal-US (based on surveys of inventors in the U.S.).

Although surveys are free of the matching accuracy problem, this method can not encompass the whole population of inventors, and the number of inventors surveyed as well as the response rate can be quite low. Furthermore, the survey data can be subject to sample selection problems such as lower response rates among inventors with lower productivity.[2)]

The reason for the difficulty in constructing inventor-level panel data from patent records is the unavailability of unique IDs for inventors in all patent databases around the world. One exception in this regard is the Korean patent database.

The Korean Intellectual Property Office (KIPO) has been collecting inventors' resident registration numbers for nonpublic use at the time of patent filing since 1991. Every citizen in Korea is assigned a unique thirteen-digit number for resident registration of which the first six digits show the person's birth date (in the format of YYMMDD) and the seventh digit reveal the person's gender (1 for males and 2 for females). The rest of the digits in a resident registration number show the location of a public office where the birth of the resident was originally reported.

In the early 2010s, we were able to acquire the nonpublic patent data from the Korean Intellectual Property Office which cover the entire Korean patents filed between 1991 and 2005. The data include three extra variables of the inventor ID, the birth year and the gender of an inventor in addition to all regular variables from patent documents like filing and grant dates, assignee's name and address, inventors' names and addresses, patent classifications, citations to earlier patents, and claims. Utilizing the inventor ID, we could construct panel data at the inventor level from this database.

Our inventor panel database provides several critical advantages, among many others, over databases assembled by either the disambiguation procedure or inventor surveys. First, we can accurately estimate various performance measures of an inventor at each age from different cohorts. In other words, we can precisely identify the age and the birth cohort effects in each year of patenting. For example, we can estimate the patent productivity or the degree of expertise of an inventor at each age across cohorts (Kim and Koh, 2018).

Second, in contrast to the databases constructed from inventor surveys, our inventor panel data cover the entire population of inventors who patent. Our data comprises

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2) One merit of inventor surveys is that personal variables such as education and other socio-economic backgrounds can be obtained from those inventors surveyed.

nearly 340,000 unique inventors and 1.6 million patents filed during the sample period.

Third, we can study the gender difference in various aspects of inventor performances with our data. Our initial investigation shows that the share of female inventors is about 5 percent of all inventors.

Fourth, we can identify job turnovers among inventors more accurately than in an inventor-level dataset created by the disambiguation procedure. One typical criterion utilized by the disambiguation procedure in identifying the same inventor over multiple patents is to check whether those patents have the same assignee, which systematically makes it difficult to identify inventors who move.

Making good use of these advantages in our data, we investigate in this paper the evolution of patent productivity of an inventor over his/her career. This is our first study to use the unique panel data of Korean inventors, and we look forward to studying various other issues using the data in coming years.

The paper is organized as follows. Section II reviews theoretical and empirical works on the effect of age on labor productivity. Sections III describes the data. Our empirical specification is explained in section IV. In section V we report the result from the regression analysis. We conclude in section VI.

II. Literature Review: Age Effect of Productivity

There are numerous studies in the labor literature that investigate the effect of age on labor productivity or wage. In theory, age may have an adverse effect on productivity owing to declining physical capacity or cognitive (mental) abilities with age. Evidence in general shows decline in cognitive abilities with age (across countries and ability groups, by gender). Reasoning, perceptual speed decline sharply with age while verbal abilities remain rather unchanged. On the other hand, labor productivity may rise with age due to accumulated experience (e.g. personal network with customers, tacit knowledge) of workers.

In empirics, various measures of labor productivity or wage have been proposed in this line of research on the age effect. One of those measures is income of independent workers. This measure can be objective and easy to estimate. However, it can be applicable only to limited types of occupations.

Lazear and Moore (1984) use income data of the self-employed from the 1978 Current Population Survey, and find little income variation by age. De Oliviera, Cohn, and Kiker (1989) which study those self-employed in the 1983 Panel Study of Income Dynamics report an inverted-U shape in the age-income profile.

Another measure of labor productivity used in the literature pertains to supervisor’s evaluations of subordinate workers. Unlike the aforementioned measure, this one can be employed for all types of occupations, but may be subjective. Moreover, positive evaluations may be rather given as rewards for past performances.

Using personnel microdata on the white male managerial and professional employees at large U.S. firms, Medoff and Abraham (1981) argue that the performance ratings which supervisors give to their white male managerial and professional subordinates adequately reflect the subordinates’ relative productivity in the year of assessment and seniority is not or negatively related with performances.

Outputs of various types by an individual are another category of the productivity measure. This category includes such measures as artistic works (paintings, albums, and books, for example), professional publications, and patents. These measures can be objective, but they can be available only when individual production can be easily monitored possibly because the products are homogenous and not produced through teamwork.

Kutscher and Walker (1960), using the survey data by the Bureau of Labor Statistics, show that American office workers in government and private firms have a flat age profile of productivity. Miller (1999) studies performance outcomes of painters, musicians, and writers and reports that their productivity has a peak age at 30s-40s. Galenson and Weinberg (2000) who study the productivity of artists show that the peak age is 51 for those born before 1920, and 29 for those born after 1920.

There have been many studies that investigate the productivity of scientists or researchers in terms of academic publications. Cole (1979) reports that the age profile of research productivity for American academic scientists in physics takes an inverted-U shape with a peak at age 40-44. According to Levin and Stephan (1989), age has an adverse effect on publications among American academic scientists in physics, earth science, physiology, and biochemistry. Oster and Hammermesh (1998) find that the number of publications declines sharply with age among economists. Weinberg and Galenson (2007) report empirical results that Nobel laureates in economics have their peaks of productivity at the mid-50s for experimental laureates while at age 25 for conceptual laureates. Hall, Mairesse, and Turner (2007) find no significant effect of age on productivity of French physicists.

Studies that investigate the age effect on patenting using micro panel data are rare because of the lack of inventor IDs in patent databases as explained in section I. However, there are several papers which rely on the inventor survey data (Hoisl, 2007; Schettino et al., 2013). Hoisl (2007) relates the patent productivity of an inventor and his/her age in logarithm and finds that the latter has a negative coefficient. This implies a decreasing productivity with age.

III. Data Description

1. Data

Our empirical analysis uses the nonpublic patent data from the Korean Intellectual Property Office which are transformed to inventor-level panel data. The database includes patent applications filed between 1991 and 2005.[3] It shows that the annual count of patent applications grew from 13,039 in 1991 to 121,425 in 2005 with the average growth rate of 17 percent per year. Our database includes only domestic inventors because resident registration numbers are not available for foreign inventors. It comprises about 340,000 unique inventors.

The dataset includes information on assignees (i.e., patent right holders), ID numbers,

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[3] Data for patent applications after 2005 are not accessible due to a change in the Korean government's regulations on privacy.

birth years, genders, names and addresses of inventors, filing and issue dates, claims (itemized description of an invention), technology categories and the like which are mostly collected from the first pages of patent documents.

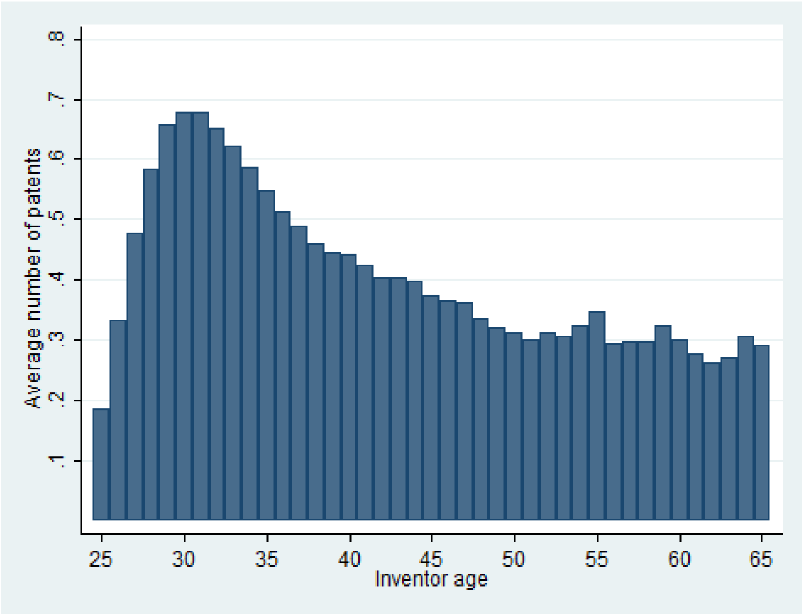
We consider an inventor listed on a patent as a producer of the invention that the patent represents. A patent-filing firm is legally obligated to list as inventors all researchers who made creative contributions to invention that underlie at least one of the patent's claims. Inventorship on patents is circumscribed rather narrowly by most patent laws. For instance, laboratory directorship is sufficient in many disciplines to earn authorship on a scientific publication, but it is insufficient to obtain inventorship on a patent. Also, persons who are technicians or merely took direction from an inventor do not legally qualify as inventors. While in practice the eligibility requirement for inventors may not always be strictly followed, including persons on the patent application who do not satisfy the legal requirement, or excluding persons who do, risks having the patent invalidated (Crawford and Kokjohn, 2009).

2. Descriptive analysis

Figure 1 shows the average annual number of patent filings per inventor at each age as a measure of inventor productivity. The age profile of patent productivity looks in this figure to take an inverted U-shape. The patent number rises with age at the earlier years of career, peaks at age 30, and declines monotonically afterwards. Note that we do not have the cohort or the year effects controlled for in Figure 1. Therefore, this figure comprises different cohorts of inventors and the shape may be influenced by productivity differences across cohorts.

In Figure 2, we plot the age productivity profile for male and female inventors separately. Panel A shows the profile for men, which is almost identical to Figure 1 because more than 90 percent of inventors are men in our data. Female inventors show in panel B a similar pattern of an inverted-U shape, but their profile looks noisier due to a small number of observations.[4)]

Figure 1. Age Profile of Patent Productivity

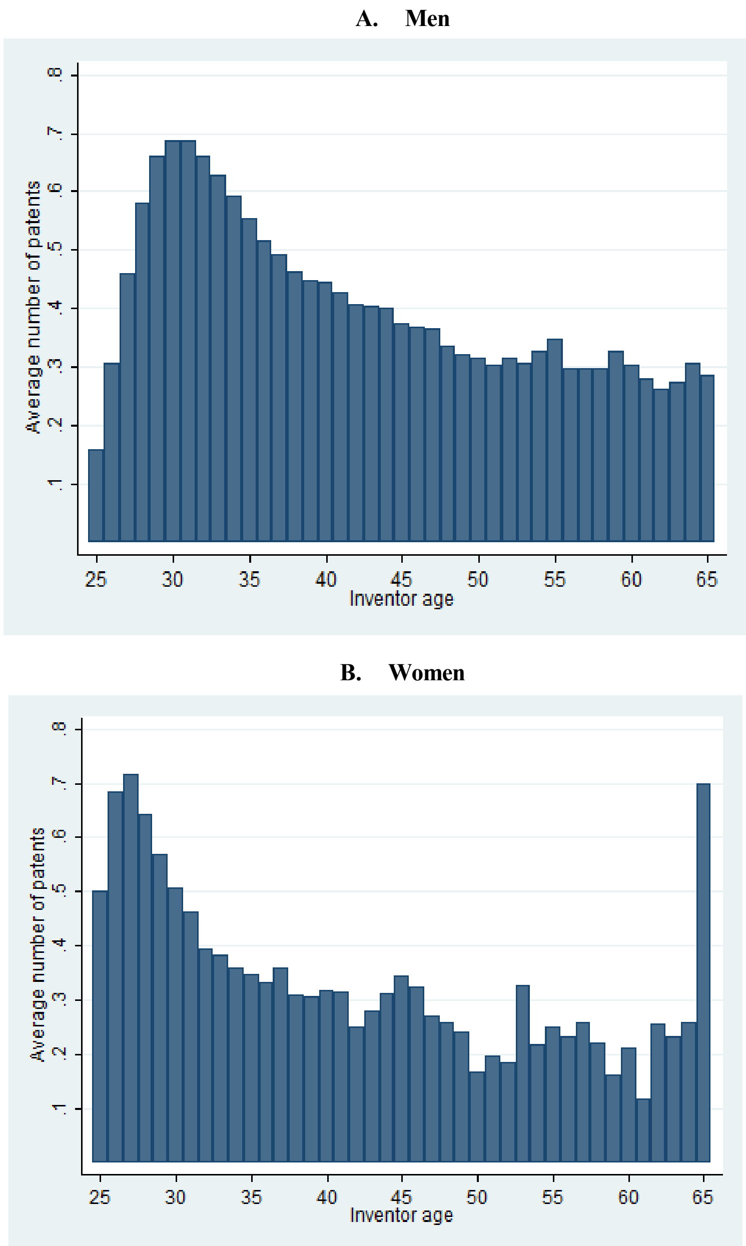


Note: This figure is from Kim (2012).

The contribution of an inventor to the invention behind a patent may be smaller when there are more inventors involved in a single patent. The alternative measure of inventor productivity we adopt is the annual count of patents each of which is weighted by the inverse of the number of inventors appearing on a patent. For example, if an inventor has a patent with two other co-inventors, the patent count for him is one third of a patent.

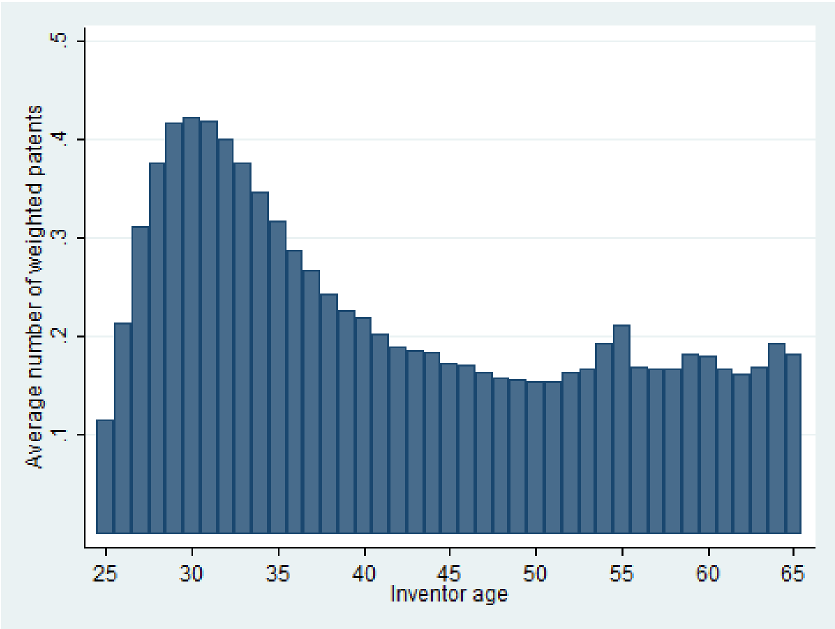
4) We find in panel B for women that the patent count is high for age 65. This may be due to the selection issue: those women who still produce inventions and are included in our data at that old age are likely to be very productive ones.

Figure 2. Age Productivity Profile: Men vs. Women



Note: These figures are from Kim (2012).

Figure 3. Age Profile of Co-Inventor-Weighted Patent Counts



Note: This figure is from Kim (2012).

Figure 3 shows the age profile of co-inventor-weighted patent count. By construction, the level of the count in this figure is lower than that in Figure 1. However, the pattern of the age productivity profile is the same: we have an inverted-U shape with a peak age of 30.

IV. Model Specification

In order to investigate determinants of inventor productivity including age, we employ a linear regression model as follows.

$$\square_{\square} = \sum_{\square=25}^{53} \square_{\square} 1\{\square\ \square = \square\} + \sum_{\square=1947}^{1976} \square_{\square} 1\{\square\ h\square\ \square = \square\} + \square\_\square_{\square} + \square' \square_{\square} + \square_{\square}\ \square \quad (1)$$

where the dependent variable y_{it} is the annual patent count of inventor i in year t. Alternatively, we use the co-inventor-weighted patent count as the dependent variable.

$I\{Age_{it} = k\}$ is an indicator variable which equals to one if inventor i's age is k in year t, and $I\{BirthYear_i = j\}$ is an indicator variable which equals to one if inventor i was born in year j where t ranges from 1991 to 2005. X_{it} is a vector of other determinants, including gender and patent-specific variables. ε_{it} is an error term.

The coefficients associated with the age indicator variables (α_k) pertains to the age effects, and the coefficients associated with the cohort indicator variables (β_j) pertains to the cohort effects. The inventor age ranges from 25 to 53 in our data while the birth year ranges from 1947 to 1976.[5] A key assumption in this specification is that the age productivity profile is common for all cohorts, and only the intercept varies across cohorts.

We set α_{25} equal to 0 in our estimation so that coefficients α_k)'s trace the age effects relative to age 25. Note that we drop inventor-level fixed effects in this specification since the cohort effects are independently estimated.

Due to the multicollinearity problem, we can not add the dummy variables for calendar years in equation (1). To isolate the calendar year effects, we postulate that the year effects (Y_D_t) result from changes in the overall propensity of patenting, and the year effects are proxied by the total annual number of applications ($TPAT$) and inventors ($TINV$) as follows:

$$
\begin{aligned}
Y\_D_t &= f(TPAT_t,\ TINV_t) \\
&\cong \phi_1\ TPAT_t + \phi_2\ TPAT_t^{\ 2} + \phi_3\ TPAT_t^{\ 3} \qquad (2) \\
&\quad + \phi_4\ TINV_t + \phi_5\ TINV_t^{\ 2} + \phi_6\ TINV_t^{\ 3}
\end{aligned}
$$

5) Those observations with age less than 25 or over 53 are excluded in our regression analysis because there are too few of them for significant estimation and we suspect errors in coding.

Table 1. Summary Statistics

Variable (Notation used in regression)	Mean	St. Dev	Min	Max
Annual patent count of an inventor	.4973565	2.088789	0	362
Co-inventor-weighted patent count	.2893795	1.40347	0	362
Inventor's age at filing	34.96835	7.184329	25	53
Birth year of an inventor	1963.96	7.068435	1947	1976
Dummy for male inventor (MALE)	.9631906	.1882936	0	1
Annual count of all patents filed (TPAT)	48859.45	20132.78	9970	82898
Annual count of unique inventors (TINV)	14186.81	4870.435	5864	21493
Annual average number of claims per patent for an inventor (CLAIM)	1.113992	3.360111	0	554
Annual average number of inventors per patent for an inventor (COINV)	.5154735	1.390558	0	39

In the second equality of equation (2), we utilize the Taylor expansion method to approximate function f with cubic terms. Table 1 reports the summary statistics and description of variables used in our analysis.

V. Empirical Results

We report the result from the regression analysis in Table 2. The baseline model in the first column includes as regressors the dummy variables for age and birth year as well as the calendar year effects (as shown in equation 2). It also includes the dummy variable for male inventors. In model (2), we use as the alternative dependent variable the co-inventor-weighted patent count of an inventor. A few additional regressors that proxy the value or quality of patents (for example, the number of claims and the number of co-inventors) are included in model (3).

Table 2. Regression Results

	(1) Baseline		(2) Weighed patent count		(3) Extra regressors	
	Coeff.	z	Coeff.	z	Coeff.	z
TPAT	0.00001	5.73	1.05E-05	8.12	1.65E-06	0.97
$TPAT^2$	-1.16E-10	-2.35	-5.44E-11	-1.64	5.04E-11	1.16
$TPAT^3$	1.14E-15	2.99	2.13E-16	0.83	-7.46E-17	-0.22
TINV	-7.10E-06	-0.48	7.23E-06	0.72	1.96E-05	1.50
$TINV^2$	3.80E-10	0.31	-8.95E-10	-1.08	-1.87E-09	-1.73
$TINV^3$	-6.38E-15	-0.20	2.56E-14	1.17	3.37E-14	1.18
MALE	0.11802	16.00	0.12282	24.74	0.08815	13.56
lnCLAIM					0.19942	56.62
CLAIM0					0.33844	13.78
lnCOINV					0.38078	92.05
COINV0					0.36063	14.83
Dummies for (a) Age (b) Birth yr.	 Included Included		 Included Included		 Included Included	
No. of obs.	2,294,089		2,294,089		2,294,089	

Dots in Figure 4 represent the estimated coefficients associated with the age dummies from the baseline model (1).[6] The dashed lines in the figure show the 95 percent confidence intervals for the estimated coefficients. We find that the estimated age profile of patent productivity takes an inverted-U shape: the productivity of an inventor rises rather rapidly in earlier years of the career and falls gradually afterwards. The peak of the productivity takes place at age 31. This pattern looks similar to that in Figure 1 except the fact that the estimated productivity falls faster.[7]

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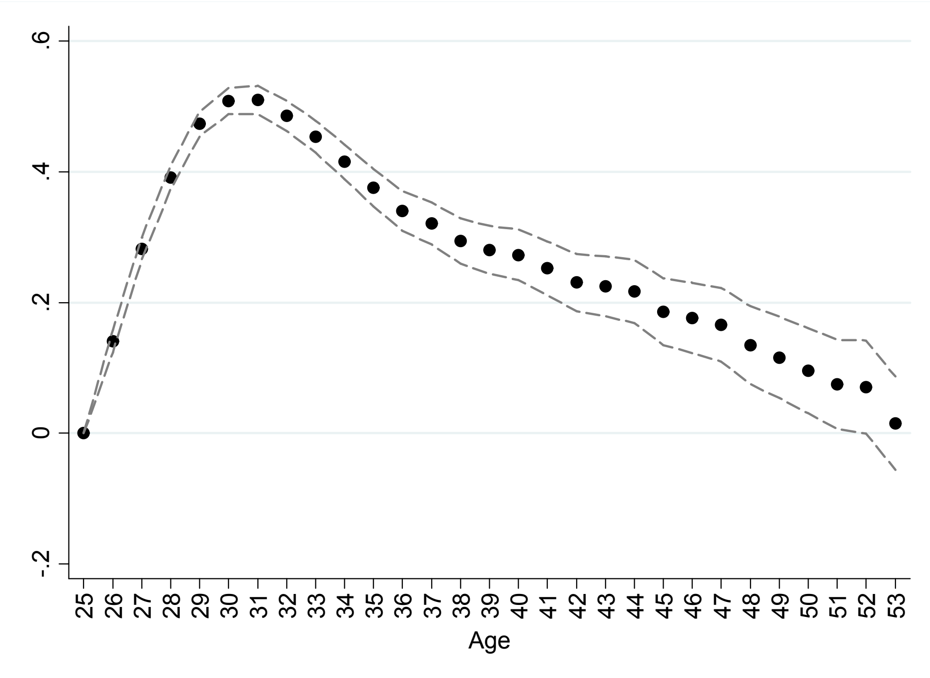
6) We do not report the estimates for the age dummies in Table 2 to save space.

7) A rapid surge of patenting in recent decades can be favorable for younger inventors to increase their productivity, which may result in the estimation of a rather young age of peak productivity. However,

Figure 4. Estimated Age Profile of Patent Productivity



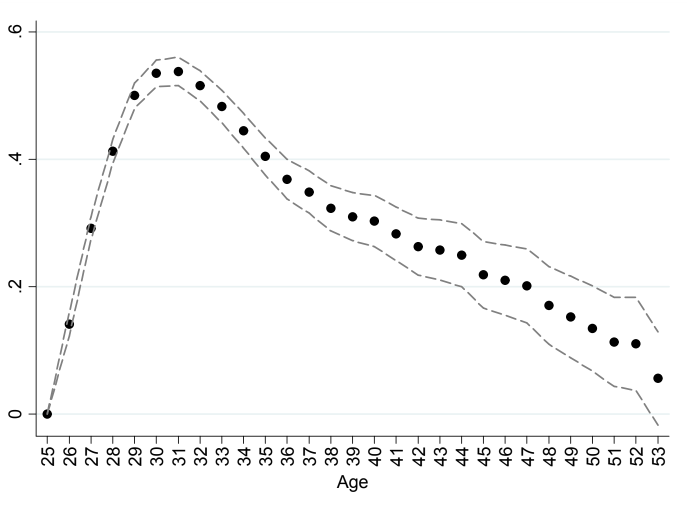
Note: This profile is based on the estimated coefficients with respect to the age dummies in model 1 of Table 2.

We estimated the age effects separately for male and female inventors (results not shown in Table 2 to save space) with the baseline specification. Panel A and B in Figure 5 show the coefficient estimates and the confidence intervals for the age effects for men and women, respectively. The estimated age profile for men is almost the same as in Figure 4, which is not surprising because 95 percent of the observations in our data pertain to male inventors. The age profile for women is shown to be inverted-U shaped like men, but it is noisier due to a small number of observations.

we find that the increase in patenting over time is more pronounced for older inventors. The number of patents by inventors age 26-30 relative to those by inventors age 41-45 was 7.9 on average in the 1991-95 period and 1.9 in the 2001-05 period.

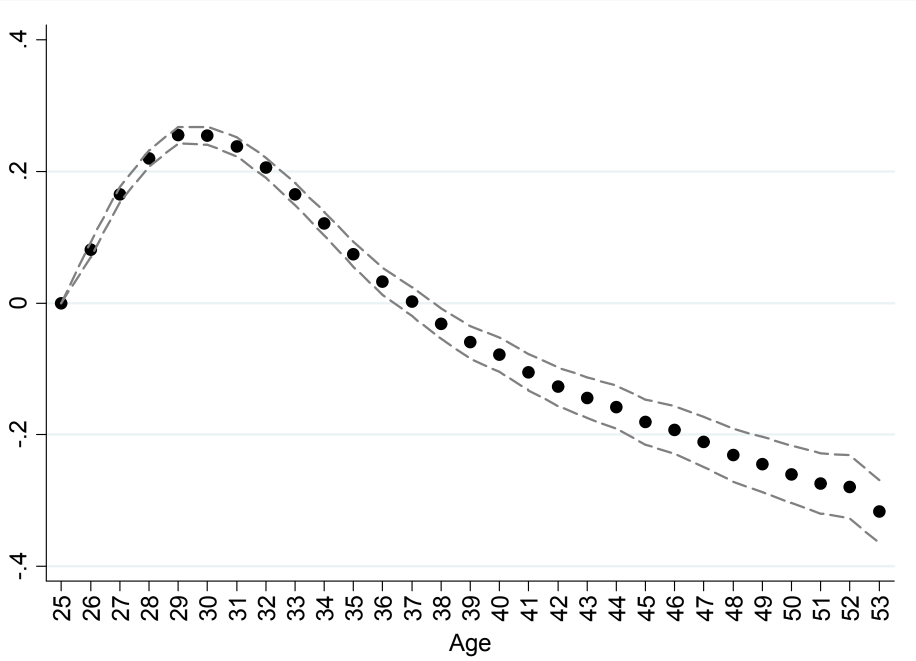
Figure 5. Estimated Age Profile of Patent Productivity: Men vs. Women

A. Men



B. Women

Figure 6. Estimated Age Profile of Patent Productivity: Co-inventor-weighted



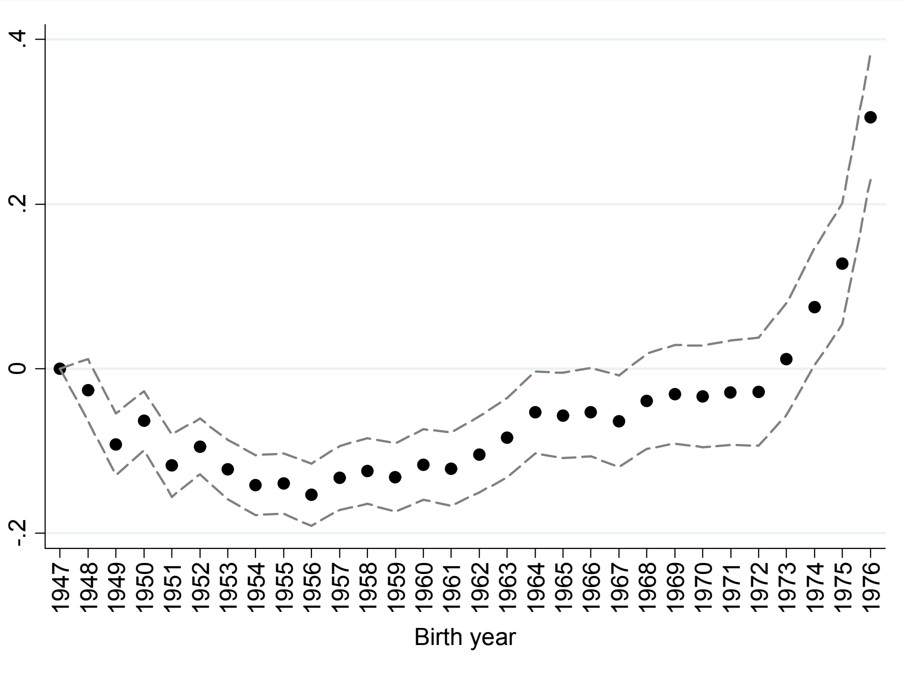
Note: This profile is based on the estimated coefficients with respect to the age dummies in model 2 of Table 2.

The estimated age profile of productivity based on the result in model 2 of Table 2 is shown in Figure 6. In this graph, we plot the weighted patent count by age with the weight of the inverse of inventor number. The pattern of the age profile in Figure 6 is similar to that in Figure 4. By construction, the weighted count should be smaller than the unweighted count and the profile in this figure is lower than in Figure 4.

We note a couple of differences in this figure with comparison to Figure 4. The decline in productivity occurs earlier in age and the productivity peak takes place at age 29, two years earlier than in Figure 4. Second, the productivity falls below the initial level (at age 25) already by age 38¾in contrast, by age 53 in Figure 4, which implies that inventors work with other co-inventors increasingly more with age.

In general, we find that the shape of the age productivity profile derived from our

Figure 7. Estimated Cohort Effects



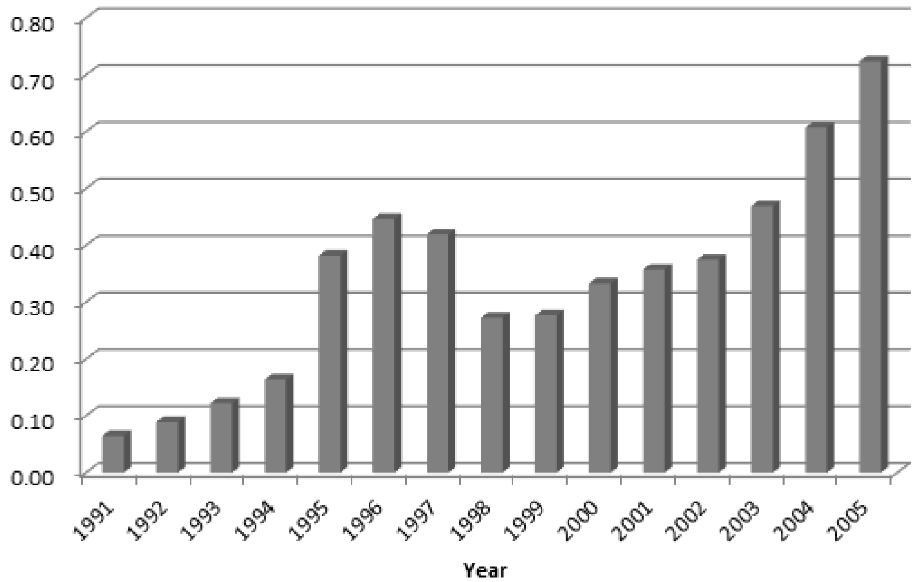
Note: This profile is based on the estimated coefficients with respect to the birth-year dummies in model 1 of Table 2.

analysis is consistent with the findings in earlier studies such as Cole (1979), Oliviera, Cohn, and Kiker (1989), Miller (1999), and Galenson and Weinberg (2000, 2007).

Variations in productivity across inventor cohorts are illustrated in Figure 7. Dots in this figure pertains to the point estimates of the coefficients associated with the birth-year dummies from our baseline model (1) while the dashed lines correspond to their 95 percent confidence intervals.

We note in Figure 7 that younger generations of inventors have become more productive, at least since the birth cohort of 1956. This rise in productivity has been accelerating. The youngest cohort in our sample (those born in 1976) is estimated to produce almost half a patent more in a year than the cohort of 1956 on average. On the other hand, the cohorts of inventors born before 1956 are shown to experience a slight decline in productivity over time.

Figure 8. Estimated Calendar Year Effects



Note: This chart shows the sum of the products of estimated coefficients in model 1 and the actual values of *TPAT* and *TINV* in each year (= $\phi_1 TPAT_t + \phi_2 TPAT_t^{\ 2} + \phi_3 TPAT_t^{\ 3} + \phi_4 TINV_t + \phi_5 TINV_t^{\ 2} + \phi_6 TINV_t^{\ 3}$)

We show the estimated calendar year effects in Figure 8. The graph is derived from the predicted values of the year effects (Y_D_t) by summing the products of the estimated coefficients (ϕ_i) in the baseline model (1) of Table 2 and the data values of *TPAT* and *TINV* according to equation (2).[8)]

In this figure, we see an upward trend in patent productivity with time. This is consistent with the general trends in patenting in Korea as well as in other countries like the U.S., Japan, and China. We note that there is a surge in the patent count per inventor in the period of 1995-97. This is largely due to the participation of Korea in the World Trade Organization (WTO). The Korean patent law was revised in 1995 in compliance with the Trade Related Aspects of Intellectual Property Rights (TRIPs)

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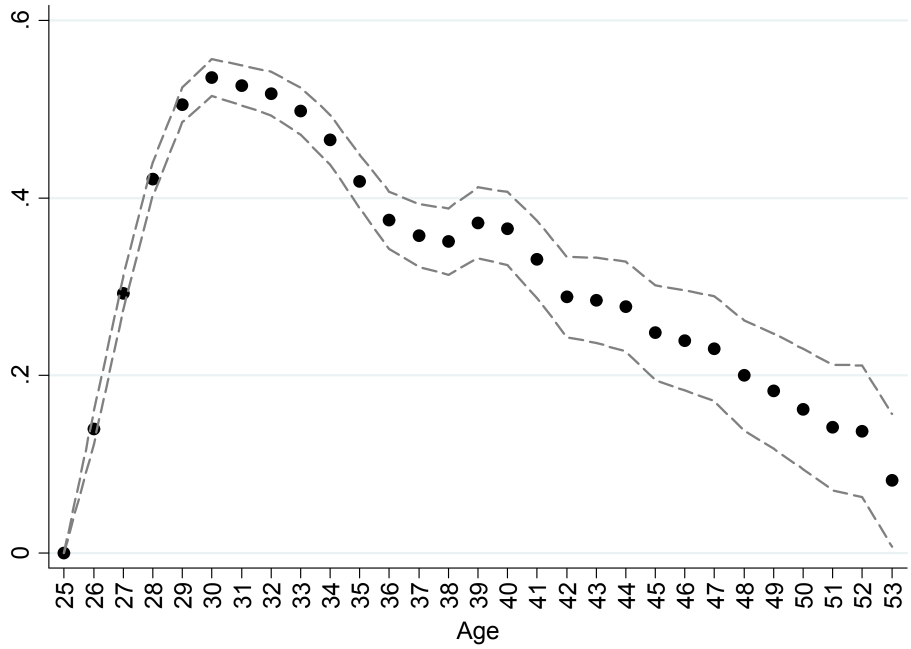
8) An F-test indicates that we should reject the hypothesis that all six coefficients associated with *TPAT* and *TINV* (ϕ_i, i = 1, 2,⋯,6) are jointly zero in model (1) of Table 2.

Figure 9. Estimated Age Productivity Profile without Those Born in 1964-66



Note: This profile is based on the estimated age-dummy coefficients (as in model 1 of Table 2) without those inventors born in 1964-66 who became 31 years old in 1995-97 (i.e. the WTO period).

under the 1994 Uruguay Round agreement which established the WTO. Anticipating more severe competition with foreign firms in the domestic product market as well as in the intellectual property market, domestic firms in Korea were trying to produce as many patents as possible for the defense purpose against foreign firms. This surge was abruptly halted after 1997 due to the Asian financial crisis in that year (Kim, 2017).

In order to check whether the event of the WTO participation has a significant impact on our estimation of productivity peak age, we constructed a sample which excludes inventors born in 1964-66 who became 31 years old in 1995-97. Figure 9 show the estimated age profile with this sample, and the profile looks quite similar to the one with the full sample.

We find in Table 2 that male inventors are more productive than female counterparts. According to the estimates in the three models in the table, the former produce about 0.1 patents more than the latter.

The result in model 3 of Table 2 reveals that productivity is higher for inventors who produce patents with more claims. If we interpret the claim count as a measure of patent quality, this finding may be due to the selection of inventors: those who are good at research produce more and better patents.

We include as a regressor in model 3 the number of co-inventors to adjust the quality of research output. R&D enterprises are shown to be organized either with bigger teams (producing more patents) or with smaller teams (producing less patents). We include as regressors in this model dummy variables for patents with zero claim and for patents with zero co-inventor (that is, single-inventor patents) because the numbers of claims and of co-inventors are included in logarithmic values.

VI. Concluding Remarks

In all patent databases from the patent offices around the world, it is challenging to uniquely identify inventors across patents because there is no inventor ID in those databases. Although a great amount of effort has been put into constructing inventor-level panel data from patent databases via the disambiguation procedure or inventor surveys, the resulting outcomes have left a lot to be desired.

Since 1991, the Korean Intellectual Property Office has collected resident registration numbers of inventors (which can provide us inventor IDs, birth years, and gender) and we make use of that information to construct the panel data at the inventor level. As the first undertaking with our data, we investigate the age profile of patent productivity among inventors.

We find that patent productivity rises rapidly and then declines gradually with age, in terms of not just the annual patent count per inventor but also the weighted number of patents. The age profile reaches a peak around age 31. This pattern of the age profile is evident for male as well as female inventors. This finding is quite consistent with those of the earlier studies in the literature on the age profile of labor productivity or wage.

With the Korean population ageing so fast, the decline of patent productivity after age 31 can pose a grave problem for R&D in Korea. Some government policies may be needed to slow down the productivity decline among inventors after 30's. A possible policy prescription is to promote cooperation and teamwork across generations of inventors so that more productive ones can have spillover effects.

We recognize several issues in our analysis that should be addressed in future work. It becomes more likely in recent years that patents are produced not by a single inventor but rather by a team. We see in our Korean patent data that the average number of inventors per patent rose from 1.5 in 1991 to 2.0 in 2005. We need to take into account different contributions by inventors with different characteristics such as age or education to calculate an inventor's productivity in a more accurate fashion.

Second, firms may vary in characteristics that can affect the patent productivity of an individual inventor of the firm. However, we do not consider characteristics of patenting firms in our regression analysis. We may want to combine our patent data with firm-level databases (such as the KisValue database) in order to address this matter.

Third, it is well noted in the literature that the value of a patent varies greatly. To tackle this issue, they have used citation information in patent data with the presumption that a patent which more subsequent patents cite is more valuable. Using citation information in the Korean patent data, we can employ this approach to proxy the value of patents and calculate the inventor productivity more precisely.[9)]

Our inventor panel data can be utilized for many further research agendas. For example, we can trace more accurately job turnovers of inventors and thus study the effect of labor mobility on various performance measures of inventors. We can also investigate the spillover effects of moving inventors on new colleagues at a destination firm.

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9) One concern in this endeavor pertains to the fact that citation information had been documented on Korean patents quite rarely until early 2000s.

Even though we have a relatively fewer number of female inventors in our panel dataset (about 17,000 women vs. 323,000 men), we still have enough observations to investigate various issues related with female labor force in research and development such as which technology fields women are interested to do research in, whether there is a significant difference in firm size between female and male inventors.

Another intriguing topic we can explore with our data regards inventor teams in research. It is fascinating to know how a research team is organized in terms of the age composition or the member's productivity level. It is also interesting to see how the team structure has been evolving over time. Are older inventors more likely to team up with younger ones lately? Are more productive inventors matched with more productive co-workers? We leave these exciting research questions for future work.

Reference

Acs, Z.J. and Audretsch, D.B. "R&D, Firm Size and Innovative Activity." in Z.J. Acs and D.B. Audretsch (eds), *Innovation and Technological Change. An International Comparison.* Ann Arbor: University of Michigan Press, 1991.

Aghion, Philippe, Bloom, Nick, Blundell, Richard, Griffith, Rachel, and Howitt, Peter. "Competition and Innovation: An Inverted-U Relationship." *Quarterly Journal of Economics* 120 (2) (May 2005): 701-728.

Cohen, W.M., and Klepper, S. "A Reprise of Size and R & D." *The Economic Journal* 106 (437) (July 1996): 925-951.

Cole, Gerald A. "Classifying Research Units by Patterns of Performance and Influence: A Typology of Round I Data." in Frank Andrews (ed.), *Scientific Productivity.* Cambridge: Cambridge University Press, 1979, pp.353-404.

Crawford, Bradley W., and Kokjohn, Sydney R. "Navigating Inventorship in the Chemical Industry." *Review of Developments in Intellectual Property Law* 7(1) (June 2009): 5-7.

De Oliviera, M. Mendes, Cohn, Elchanan, and Kiker, B. F. "Tenure, Earnings and

Productivity." *Oxford Bulletin of Economics and Statistics* 51 (1) (February 1989): 1-14.

Galenson, David W. and Weinberg, Bruce A. "Age and the Quality of Work: The Case of Modern American Painters." *Journal of Political Economy* 108 (4) (August 2000): 761-777.

Hall, Bronwyn, Mairesse, Jacques, and Turner, Laure. "Identifying Age, Cohort, and Period Effects in Scientific Research Productivity: Discussion and Illustration Using Simulated and Actual Data on French Physicists." *Economics of Innovation and New Technology* 16(2) (March 2007): 159-177.

Hoisl, Karin. "Tracing mobile inventors-The causality between inventor mobility and inventor productivity." *Research Policy* 36(5) (June 2007): 619-636.

Kim, Jinyoung. "Korean Technology Researchers and Patent Productivity." *Analysis of Korean Economy* 18(2) (August 2012): 1-35 (*in Korean*).

Kim, Jinyoung. "Labor Mobility and Inventor Productivity." Working paper, Korea University, 2017.

Kim, Jinyoung, and Koh, Kanghyock. "Jack of Less Trades: Evidence on the Evolution of Specialization in Research." Working paper, Korea University, 2018.

Kim, Jinyoung, Lee, Sangjoon J., and Marschke, Gerald. "International Knowledge Flows: Evidence from an Inventor-Firm Matched Data Set", *Science and Engineering Careers in the United States*. Richard B. Freeman and Daniel F. Goroff (eds), Chicago, IL: University of Chicago Press for NBER Science Engineering Workforce Project, pp.321-348, 2009.

Kutscher, R.E., and Walker, J.F. "Comparative Job Performance of Office Workers by Age." *Monthly Labor Review* 83 (January 1960): 39-43.

Lai, R., D'Amour, A., and Fleming, L. "The careers and co-authorship networks of US patent-holders, since 1975." Unpublished Working Paper, Harvard University, 2009.

Lazear, Edward P., and Moore, Robert L. "Incentives, Productivity, and Labor Contracts." *Quarterly Journal of Economics* 99 (2) (May 1984): 275-296.

Levin, Sharon G., and Stephan, Paula E. "Age and Research Productivity of Academic

Scientists," *Research in Higher Education* 30 (5) (October 1989): 531-549.

Medoff, James, and Abraham, Katharine. "Are Those Paid More Really More Productive? The Case of Experience" *Journal of Human Resources* 16 (2) (Spring 1981): 186-216.

Miller, G. F. "Sexual selection for cultural displays." In R. Dunbar, C. Knight, & C. Power (eds.), *The Evolution of Culture.* New Brunswick, Rutgers Univ. Press, 1999.

Nickell, Steven. "Competition and Corporate Performance." *Journal of Political Economy*, CIV (August 1996): 724-746.

Oster, Sharon M., and Hamermesh, Daniel S. "The Research Productivity of Economists." *Review of Economics and Statistics* 53 (1) (February 1998): 154-156.

Scherer, F. M. "Market Structure and the Employment of Scientists and Engineers." *American Economic Review* 57(3) (June 1967): 524-531.

Schettino, Francesco, Sterlacchini, Alessandro, Venturini, Francesco. "Inventive productivity and patent quality: Evidence from Italian inventors." *Journal of Policy Modeling* 35 (6) (Nov.-Dec. 2013): 1043-1056.

Schumpeter, Joseph. *Capitalism, Socialism and Democracy*, London, Allen Unwin, 1943.

Trajtenberg, M., Shiff, G., and Melamed, R. "The "names game": Harnessing inventors' patent data for economic research." NBER Working Paper No. 12479, 2006.

Weinberg, Bruce A., and Galenson, David W. "Creative Careers: The Life Cycles of Nobel Laureates in Economics." NBER Working Paper No. 11799, 2007.

abstract

한국 개발자 패널데이터를 이용한 기술개발자의 생애주기 생산성 분석

김 진 영

1980년대 이후 특허 데이터를 이용한 많은 연구가 있었지만, 특허문서에 나온 기술개발자의 정보를 이용한 연구는 큰 진전을 이루지 못하였다. 이는 해외 모든 국가의 경우 특허에 기재된 개발자의 이름만으로는 동일인 파악이 어렵기 때문이다. 한국 특허 데이터에 포함된 개발자의 식별번호, 생년, 그리고 성별 정보를 이용하여, 본 연구는 생애주기에서 개발자의 기술개발 생산성이 어떻게 변하는지, 세대별로 생산성의 향상이 있었는지 분석하였다. 앞으로 이 개발자 패널데이터를 이용하여 기술개발의 중요한 요소인 기술인력에 관한 연구가 크게 진전되리라고 기대한다.

주제어: 특허, 기술개발, 개발자, 생산성, 생애주기