1 Empirical Analysis

This section presents five main findings that apply to the periods under consideration: (i) effective inventors became more concentrated across economic sectors; (ii) sectors with increased product market concentration attracted a growing share of relevant inventor types; (iii) growth in the share of relevant inventors negatively correlated with inventor productivity, as measured by forward citations as well as average growth in output per worker divided by effective inventors employed; (iv) growth in the share of inventors coincided with increased concentration of inventors *within* sectors; and (v) growth in inventor shares are positively correlated with increases in patent enforcement cases.

Results (i) and (ii) indicate a positive causal link between the growth in product market concentration and the increase in sectors' inventor share. Findings (iii), (iv) and (v) point to misallocation: Inventor concentration in less competitive sectors turns out to be inefficient, as researchers are predominantly employed on projects that do not contribute to the growth of the sector. This work amounts to defensive innovation, as evidenced by the decline in forward citations of patents obtained by these firms, the decrease in growth per inventor, and the increase in patent litigations that accompany the increase in product market concentration. I discuss the causal interpretation of my results through an IV specification in Subsection 1.2.

1.1 Variable Definitions and Main Specification

Key to my analysis are measures of inventor concentration and of R&D productivity. I rely on the definition of effective inventors, α_i, explained in Section **??**. For each product market p, I define the share of inventors employed by the sector in year t as

$$\text{Inventor Share}_{p,t} \equiv \frac{\sum_{p(i,t)=p} \alpha_i}{\sum_{k(i,t)=k} \alpha_i},$$

where the numerator sums effective inventors in product market p, and the denominator computes total effective inventors in the relevant knowledge market. I also use effective inventors α_i to evaluate the dispersion of inventors across sectors. Results are robust to using raw counts of researchers instead of effective inventors.

When analyzing R&D productivity I focus on two patent-based measures described in Section **??**—forward citations and patent generality. Further, I compute a more direct measure of the productivity of inventors as the growth in output per worker divided by the number of effective inventors employed by the sector.

In most specifications, the independent variables are measures of concentration and controls for the size of the sector considered. As discussed in Section **??**, my baseline measure of concentration is the lower bound of the Herfindal-Hirschman Index constructed by **?**, which I label $\underline{\text{HHI}}_{p,t}$. I show below that the Economic Census HHI and its lower bound, when both available, produce equivalent results.

I obtain measures of sales from the Economic Census, which I deflate using BLS NAICS-specific price indexes. I use sales variables for two purposes. First, real sales in 2012 are the weight in my regressions. Second, I use the logarithm real sales as well as a quartic in real sales to control for changes in the size of sectors during my sample period. For the selected subset of sectors that reports the number of companies, I show that my findings are robust to controlling for sales per company, a proxy for the average firm size.

I estimate a sector-level long-difference regression over the period 1997-2012

$$\Delta \text{Share}_{p,\,2012-1997} = f_k \mathbf{1}\left\{p \in k\right\} + \beta \Delta \underline{\text{HHI}}_{p,\,2012-1997} + \gamma' \Delta \text{Size}_{p,\,2012-1997} + \varepsilon_p, \tag{1}$$

where ΔShare denotes the change in the inventors' share of product market p; $f_k \mathbf{1}\left\{p \in k\right\}$ is a dummy variable that takes value 1 if the product market belongs to knowledge market k; $\Delta\underline{\text{HHI}}$ is the change in the HHI lower bound; and ΔSize is a set of controls for the size of sector p. Depending on the specification, ΔSize is the change in log real sales, the change in log real sales per firm, or a quadratic polynomial in real sales changes.

Regressions are weighted by sector sales in 2012 for the findings which rely on Economic Census sector-level measures, and I estimate robust standard errors in all specifications. When looking at patent measures, I employ the same specification as in equation 1, where I replace the outcome variable with the change in patent productivity and the independent variable with the change in inventors' share.[1] In this case, since I do not rely on Economic Census measures, I report unweighted regressions. I discuss the robustness of these findings to using the HHI lower bound and weighting by sales.

1.2 Results

1.2.1 Inventor Concentration across NAICS Sectors has Increased

Figure 1 reports the time series of inventor concentration across NAICS 4-digit industries for the period 1976-2016, for which the **?** data is available. Panel (a) depicts the share of effective inventors and panel (b) that of raw inventors. I use the HHI index of inventor shares accruing to each sector as a measure of concentration. Both panels display an increasing concentration of inventors beginning in the late 1990s. The increase in inventor concentration is sizable, corresponding to about a 20% increase in the HHI for the effective inventor measure over the period 1997-2012. Based on raw inventor data, the figure rises to 30%. Figure 1 extends the findings in **?**, who document a rising share of patents registered

[1] As I will show, the change in the inventor share is highly correlated with the change in the HHI, so this specification essentially amounts to a rescaling of the coefficient that would be obtained using the HHI.

Figure 1: Inventor Concentration, NAICS 4-digit Industries, 1976-2016

[every plot/.append style=line width=2pt,] [width=6.028in, height=4.754in, at=(1.011in,0.642in), scale only axis, unbounded coords=jump, xmin=1978, xmax=2016, xlabel style=font=, xlabel=Year, ymin=0.039, ymax=0.053, ylabel style=font=, ylabel=Inventor Share HHI, axis backg

Note: This figure reports the time series of inventor concentration, as measured by the HHI index of inventor shares across NAICS 4-digit sectors. The left panel reports the series constructed using effective inventors as defined in Section **??**, the right panel uses instead raw inventor counts. Only the NAICS 4-digit sectors with data for all years are included.

by top firms within sectors, to the cross-industry allocation of inventors.[2] As for the results presented below, the effective inventor measure and the raw inventor count behave similarly, although the figure for effective inventors is less volatile since this measure derives from a regression that residualizes time, firm, and technology class fixed effects.

1.2.2 Markets with Growing Concentration Increased Their Inventor Share

In this section, I present three sets of results for each specification, which differ in the estimation sample to account for extreme observations. In regression tables, "Full Sample" refers to the sample of observations with non-missing observations for all the variables included. I propose two sample selections to rule out that outliers drive the baseline results. "Trim Outliers" refer to a sample that excludes the most extreme observations for the outcome and the independent variable. I exclude the observations that fall beyond three standard deviations from the sample average of each variable and that are most likely to drive the results estimated using the full sample.[3] "Mahalanobis 5%" denotes the sample where I exclude the 5% extreme observations based on the Mahalanobis distance of pairs of observations from the data centroid. This procedure is based on the joint distribution of outcomes and independent variables, which may result in a different sample for each regression.

Table 1 presents the results of regression (1) where the outcome variable is the change in knowledge-market inventor share, and the independent variable is either the change in the lower bound of the Herfindal- Hirschman Index discussed above or that in the index as reported by the Economic Census. The results in Table 1 highlight a strong positive correlation between the change in the HHI and the change in the share of effective inventors accruing to each NAICS sector. Note that this regression is only partially driven by the contemporaneous correlation between the two variables. As discussed above, the share of effective inventors is averaged over the five years *starting* in the Economic Census year, while the concentration measures refer to the Economic Census year only.

Two important notes on the scale of the variables are in order. First, here and in all following tables and graphs, all variables that refer to shares or growth rates are reported in percentage points for ease

[2] A similar pattern emerges for concentration in specific CPC classes (available on request).

[3] I justify the choices for each variable in detail in my replication code using the empirical kernel density and detailed tabulations.

Table 1: Regressions of Change in 4-digit Knowledge Market Share over Change in HHI Measures, Long-Differences, 1997-2012

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \underline{\text{HHI}}$	27.293*		27.183*		27.326*	
	(11.569)		(11.941)		(11.620)	
Δ HHI		22.399***		22.399***		22.350***
		(6.345)		(6.345)		(6.343)
Sample	Full	Full	Trimmed	Trimmed	Mahalanobis	Mahalanobis
Weight	Sales	Sales	Sales	Sales	Sales	Sales
N	157	80	155	80	150	71

Note: Regressions weighted by sales in 2012; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p<0.1,^{*}\ p<0.05,^{**}\ p<.01,^{***}\ p<.001\right)$; N is the number of observations. This table presents the results of specification (1), regressing sector p's share of effective inventors in knowledge market k, over the HHI lower bound for product market p, or the HHI index. "Full", "Trimmed" and "Mahalanobis" refer to the samples described in the main text.

of interpretation. With regard to the coefficient in Column (1) of Table 1, for example, an increase in one unit of the HHI index leads to an increase in the share of the relevant knowledge market of 27.25 percentage points. Second, HHI indices are constructed to range between 0 and 1. In 2012, the HHI lower bound has a sales-weighted average of .03 and a standard deviation of .032. According to Table 1, a standard deviation increase in this measure is associated with a .87 percentage point increase in the share of inventors accruing to the relevant NAICS sector. In comparison, the sales-weighted average share of inventors in 2012 is 1.18%, with a standard deviation of 1.82%, so the estimated effect of a one standard deviation increase in concentration corresponds to about half a standard deviation increase in the share of inventors in the relevant market. The estimates using the HHI lower bound tend to be noisier as this is a constructed, and therefore imprecise, measure of concentration. However, the number of available observations is much larger than the actual HHI, allowing me to extend my findings to about double the number of sectors.[4]

While suggestive, the correlation presented above neglects two fundamental components. First, it does not include controls for the size of the sectors or firms, which could have a mechanical effect on the share of scientists. Second, it estimates the correlation both across and within knowledge markets. In Table 2, I address these two limitations by restricting the analysis to within knowledge markets, and controlling for two measures of size. In the upper panel of Table 2, the change in the logarithm of real sales serves as a measure of the change in the size of each sector, while the lower panel shows the results when average sales per firm are included as a control. I include sales per firm to account for the fact that there might be significant barriers to entry in R&D, easier to overcome for larger firms, thus mechanically linking concentration and inventor shares. Since the Economic Census reports the number of companies only for a subset of firms, the sample in the lower panel is smaller. The results

[4] Regressions using the Economic Census HHI not reported in the main text or the Appendix are available on request.

in are largely unchanged relative to the baseline estimates. These findings imply that sectors with increasing concentration have attracted a rising share of scientists above what would be predicted by their expansion in overall sales and in average firm size. Results are also robust to using the raw number of inventors to compute inventor shares.

Appendix Table **??** shows estimates using the share of effective inventors of each product market over the total. This amounts to neglecting the fact that inventors flow only across sectors that can employ their skills. In this specification, I find a significant, albeit small, effect of product market concentration on the share of inventors. However, this result only arises when the sample is trimmed to remove outliers. This is not surprising, considering that mismeasuring the labor market for inventors should bias the estimates of inventor mobility towards zero, since many of the sectors would not be routinely connected by inventor flows. Additionally, this result conforms with the findings in Table 2, which show that including knowledge-market fixed effects does not alter the coefficients significantly, suggesting that flows across knowledge markets are indeed negligible.

Appendix **??** establishes the robustness of all the findings in this section to the use of raw inventor counts rather than effective inventors to compute both inventor shares and knowledge markets.

IV Results More concentration could be the result of increasing technological entry barriers as incumbents hire more R&D inventors. In this scenario, the causality would flow from increased inventor shares to higher concentration. Above, I tried to mitigate this concern using as outcome variable the average share of inventors following the Economic Census years to which the HHI refers. However, reverse causality could still be present if the autocorrelation of inventor shares is sufficiently high. As a consequence, I have calculated 2SLS estimates that instrument the change in the HHI lower bound with changes in product market restrictions, as measured by the Mercatus dataset RegData 4.0. Theoretically, an increase in restrictions should raise barriers to entry in affected product markets, thus leading to higher concentration. As discussed below, such proves to be the case empirically, validating sector-specific restrictions as an instrument for concentration. A violation of the exclusion restriction requires a causal connection between product market regulations and the share of inventors hired by each sector, independent of product market concentration. For example, regulations affecting existing technologies might require more inventors to meet product market restrictions. However, this effect is unlikely to be sufficiently large and persistent to be captured by my measure of inventor shares. Further, the regulations counted in RegData are not exclusively product restrictions, but also include reporting obligations and other legal burdens unrelated to technological components. In addition, while product restrictions might certainly induce a change in the direction of innovation, there is no a priori reason to believe that the scale of innovation activity should increase. These considerations lead me to believe that the exclusion restriction is not likely to be violated.

The results of the 2SLS estimation are presented in the upper panel of Table 3. The specification is

Table 2: Regressions of Change in 4-digit Knowledge Market Share over Change in HHI Lower Bound, Long-Differences, 1997-2012

(a) Controlling for Change in Log Real Sales

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\underline{HHI}$	26.093*	22.509*	25.904*	22.716*	26.111*	22.554*
	(10.696)	(10.848)	(11.124)	(10.948)	(10.725)	(11.019)
Δ log Sales	0.914**	0.548*	0.881**	0.539*	0.918**	0.562*
	(0.278)	(0.243)	(0.275)	(0.242)	(0.283)	(0.261)
Knowledge Market FE		✓		✓		✓
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	157	153	155	152	150	139

(b) Controlling for Change in Log Real Sales per Company

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\underline{HHI}$	35.230**	20.783+	35.230**	20.783+	35.154**	22.854*
	(12.759)	(10.615)	(12.759)	(10.615)	(12.647)	(11.197)
Δ log Size	0.175	-0.040	0.175	-0.040	0.300	-0.055
	(0.382)	(0.253)	(0.382)	(0.253)	(0.460)	(0.346)
Knowledge Market FE		✓		✓		✓
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	81	79	81	79	75	67

Note: Regressions weighted by sales in 2012; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p<0.1,^{*}\ p<0.05,^{**}\ p<.01,^{***}\ p<.001\right)$; checkmarks indicate the inclusion of fixed effects. “Full Sample”, “Trim Outliers” and “Mahalanobis 5%” refer to the samples described in the main text. See notes to Table 1.

Table 3: IV Regressions of Change in 4-digit Knowledge Market Share over Change in HHI Lower Bound, 2SLS Long-Difference, 1997-2012

(a) 2SLS Results

	Δ Inventor Share (pp)	
	(1)	(2)
$\Delta\underline{\text{HHI}}$	32.426+	30.096+
	(16.987)	(15.819)
	[4.850, 99.013]	[4.415, 92.104]
Δ log Sales		0.525*
		(0.247)
Knowledge Market FE	✓	✓
Sample	Full Sample	Mahalanobis 5%
Weight	Sales	Sales
Observations	157	150
First-Stage F	4.656786	4.753009
Anderson-Rubin p-value	.0298009	.0321185

(b) First Stage and Reduced Form

	Δ Inventor Share (pp)	$\Delta\underline{\text{HHI}}$
	(1)	(2)
Δ log Restrictions	0.478*	0.016*
	(0.220)	(0.007)
Δ log Sales	0.539+	-0.000
	(0.274)	(0.005)
Knowledge Market FE	✓	✓
Sample	Full Sample	Full Sample
Weight	Sales	Sales
Observations	153	153

Note: Regressions weighted by sales in 2012; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001\right)$; checkmarks indicate the inclusion of fixed effects. This table presents the results of specifications (1), regressing changes in the share of effective inventors of sector p over changes in the lower bound of the Herfindal-Hirschman Index for product market p. $\underline{\text{HHI}}$ is instrumented by the change in log-restrictions relevant to the NAICS sector. The lower panel present first-stage and reduced-form relations. Samples are described in the main text.

Table 4: Regressions of Change in Inventor Distribution Measures over Change in 4-digit Knowledge Market Share, Long-Difference, 1997-2012

	Ch. Inv. 90/50 Quantile Ratio	Δ Top 10%/Bottom 50%	Ch. Inv. Top-50/Bottom-50 S
	(1)	(2)	(3)
Δ Inventor Share (pp)	0.211+	0.243*	0.314+
	(0.107)	(0.097)	(0.184)
Δ log Sales	-0.100	0.328	0.147
	(0.122)	(0.294)	(0.316)
Knowledge Market FE	✓	✓	✓
Sample	Full Sample	Full Sample	Full Sample
Weight	Sales	Sales	Sales
Observations	118	118	118

Note: Regressions weighted by sales in 2012; robust standard errors in parentheses; symbols denote significance levels $(+\ p<0.1,^{*}\ p<0.05,^{**}\ p<.01,^{***}\ p<.001)$; checkmarks indicate the inclusion of fixed effects. Please refer to notes in Table 2 for further details. Column (1) uses the ratio in the 90 percentile of effective inventors to the median as the outcome variable. Column (2) use the share of inventors accruing to the top 10% over the share accruing to the bottom 50% of the distribution within each NAICS sector.

the same as in Column (2) of 2, including both knowledge market and sale change fixed effects. These estimates are statistically indistinguishable from the ones reported in the baseline regression, and equally significant as highlighted by the Anderson-Rubin p-value and the corresponding confidence intervals in square brackets. The latter is the most appropriate measure of significant since the first-stage F clearly indicates that instruments are weak. This is unsurprising since, as detailed above, both the HHI lower bound and the regulation measures are estimated. In particular, I had to impute regulations for a large part of the sample using the cosine-similarity between product market restrictions.[5] The results in the lower panel of Table 3 show that instruments are relevant. The first-stage t-statistic for the regression of the change in the HHI lower bound over log-regulations is 2.07, with a 0.041 p-value. The reduced form regression of inventor shares over log restrictions is equally highly significant, leading the SW underidentification test to rejects the null hypothesis at a 5% confidence level.

Taken together, the results presented in this section establish a causal link between the increase in inventor concentration and the shifts in product market concentration.

1.2.3 Sectors that Attracted More Researchers Saw Increasing Top Firms' Inventor Shares and Falling Patent Forward Citations

While the findings presented so far establish a connection between inventor and product market concentration, they do not establish that changes in the distribution of researchers across sectors are inefficient. It would not be unreasonable, for example, to think that more concentrated sectors

[5] Using only available sectors requires dropping two thirds of the observations. See Appendix **??** for details on data construction.

Table 5: Regressions of Changes in Forward Citation over 4-digit Knowledge Market Share, Long-Differences, 1997-2012

	Δ log Citations/Patent		Δ Patent Generality
	(1)	(2)	(3)
Δ Inventor Share (pp)	-0.197***	-0.227***	-0.004
	(0.044)	(0.051)	(0.004)
Δ log Sales	-0.234*	-0.258+	0.008
	(0.112)	(0.148)	(0.013)
Knowledge Market FE	✓	✓	✓
Sample	Full Sample	Full Sample	Full Sample
Observations	153	153	153

Note: Unweighted regressions; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p<0.1,^{*}\ p<0.05,^{**}\ p<.01,^{***}\ p<.001\right)$; checkmarks indicate the inclusion of fixed effects. This table present the results of specification (1), regressing the log-change in forward citations and the change in patent generality in sector p over changes in the sector's share of inventors. Column (1) and (2) present the results for forward citations corrected for truncation as described in the text. Column (3) presents results on the patent generality measures. All columns exclude self-citations.

saw increased entry as a result of the higher rents captured by incumbents. Table 4 shows that the opposite occurred. Specifically, the share of effective inventors accruing to top inventor-hiring firms increased in the sectors that attracted more inventors over the period considered, relative to firms with fewer inventors in the sector—a finding consistent across a variety of measures displayed in Columns (1) to (6). These outcomes suggest that inventors have increasingly concentrated among large incumbents, that is, sectors that increased their inventor share also saw a *within-sector* increase in inventor concentration.

Throughout this section, I present results using changes in inventor shares to focus directly on the correlation between inventor transitions and their within-sector distribution. I verify that these findings are robust to using the change in the HHI rather than the inventor share, as should be expected from the strong correlation between these two variables reported above. Results obtained using this independent variable are available upon request.

My next finding suggests that inventor concentration is driven by a rise in defensive innovation, that is R&D aimed at protecting the incumbents' dominant position and raising barriers to entry. Table 5 shows that inventors' concentration in specific sectors went hand in hand with a fall in forward citations for patents, a standard measure of a patent's contribution to further innovations (**?**). The result in Columns (1) and (2) report two different measures of forward citations that differ in how the series are corrected for truncation. As discussed in Section **??**, the measure in Column (2) uses the procedure delineated by **?**, computing the forward citation lag distribution conditioning on the technology class of the cited patent. Column (2) also conditions on the technology class of citing patents. Column (3) presents the estimates relative to patent generality, a measure of patent impact that increases with the

Table 6: Regressions of Changes in Inventor Productivity over Changes in Inventors' Share and HHI, Long-Difference, 1997-2012

(a) Change in Inventors' Share as Independent Variable

	Δ Growth/Inventor (pp)			
	(1)	(2)	(3)	(4)
Δ Inventor Share (pp)	-0.007**	-0.005*	-0.007**	-0.005*
	(0.002)	(0.002)	(0.002)	(0.002)
Δ log Sales		-0.051*		-0.054*
		(0.021)		(0.021)
Knowledge Market FE	✓	✓	✓	✓
Sample	Full Sample	Full Sample	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales
Observations	101	101	96	93

(b) Change in HHI as Independent Variable

	Δ Growth/Inventor (pp)			
	(1)	(2)	(3)	(4)
Δ$\underline{\text{HHI}}$	-0.332**	-0.292*	-0.332**	-0.290*
	(0.113)	(0.123)	(0.114)	(0.126)
Δ log Sales		-0.052*		-0.053*
		(0.021)		(0.022)
Knowledge Market FE	✓	✓	✓	✓
Sample	Full Sample	Full Sample	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales
Observations	101	101	98	94

Note: Regressions weighted by sales in 2012; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001\right)$; checkmarks indicate the inclusion of fixed effects. Inventor productivity is average growth in output per worker over the five years starting in the Economic Census year over total effective inventors in each sector.

scope of application. The regressions in this table are unweighted since they rely only on patent data, but results are robust to using the HHI as a regressor and weighting by sales. I find a highly significant negative relation between changes in inventor shares and the fall in forward citations. A 1 percentage point increase in the share of inventors leads to a 0.2% reduction in forward citations.

The fall in forward citations is a first indication of the presence of defensive innovation (see, e.g., **?**). In the next section, I show that these patents also appear to do relatively little to boost productivity, as measured by growth in output per worker.

1.2.4 Markets with Growing Inventor Shares Saw a Fall in Inventor Productivity

Table 6 presents the results of running (1) when the outcome is the average growth in output per worker per effective inventor. I use growth in annual output per worker provided by the Economic Census and average this measure over the five-year window starting in the Economic Census year, and I analogously build a measure of average effective inventors over the same period. Inventor productivity is then defined as average output per worker growth divided by average number of effective inventors.

Both the outcome and the dependent variable are measured in percentage points. Table 6 reveals a negative and significant correlation between the increase in the number of effective inventors and inventor productivity, regardless of the independent variable employed and the sample restriction adopted.

Starting from the upper panel of Table 6, the median change in the share of effective inventors over the period was .014pp, while the measure of effective inventors has a median of 2018.[6] The coefficient for concentration in Column (4) implies a fall of .15pp ($-.005 \times .014\text{pp} \times 2018$) in average annual labor productivity growth. This number decreases to $-.28$pp when considering only sectors with positive growth in labor productivity, which accounted for the bulk of the increase in inventor shares. An alternative back-of-the-envelope computation, using the change in product market concentration to predict the change in inventor shares gives even starker results. Using the coefficient in Column (2) of Table 2(a) and considering a median change in the HHI of 0.002 yields an increase in the share of effective inventors in concentrating sectors of 0.045pp. This implies a fall in average labor productivity implied by misallocation of 0.45pp. While these numbers might appear large considering the entirety of the economy, it is worth noting that my sample includes mainly manufacturing and retail sectors, which experienced a sizable reduction of $2.73pp$ in average annual productivity growth from 1997 to 2012, driven by a steep decline in output per worker growth in manufacturing. Therefore, the mechanism I propose would explain around 15 percent of the observed decrease in output per worker growth in these sectors.

The estimates in the lower panel of Table 6, which uses the HHI instead the change in inventor shares as independent variable, imply even larger growth effects. Using the estimates in Column (2), a median HHI change of 0.02 and a median number of effective inventors of 1421 in sectors with growth in inventor shares implies a -0.78pp change in output per worker growth from misallocation, with a confidence interval ranging from -0.13pp to -1.45pp. The midpoint of these estimates would explain 28.6% of the observed fall in output per worker growth over the sample period (-2.73pp), with bounds ranging from 4.8% to 53%.

1.2.5 Markets with Growing Inventors' Share Saw Increased Patent Litigation

I restrict my attention to the period 2002 to 2012, where data on patent litigation cases are available.[7] I employ the specification in (1), now differencing over the horizon 2002-2012, and using as dependent variable the number of litigations per 1000 patents, computed as described in Section **??**. I weight the regressions by the number of patents registered in each sector in 2012, as sectors with few patents might otherwise drive the results. Column (2) in Table 7 implies that 1pp increase in the share of

[6] Recall that effective inventors in each year are measured as the sum of inventor fixed-effects in each year, and therefore do not represent the simple count of inventors.

[7] My main results are robust to this sample restriction (tables available upon request).

Table 7: Regressions of Changes in Litigations over Changes in Inventor Shares , 2002-2012

	Δ Litigations/(1000 Patents)				
	(1)	(2)	(3)	(4)	(5)
Δ Inventor Share (pp)	3.468***	3.610***	3.236**	3.343***	3.490***
	(0.829)	(0.909)	(0.993)	(0.832)	(0.881)
Δ log Sales		-1.211			-1.305
		(3.850)			(4.127)
Knowledge Market FE	✓	✓	✓	✓	✓
Sample	Full Sample	Full Sample	Full Sample	Mahalanobis 5%	Mahalanobis 5%
Weight	Patents	Patents	Patents	Patents	Patents
Observations	154	154	79	147	147

Note: Regressions weighted by number of patents; robust standard errors in parentheses; symbols denote significance levels $\left(+\ p<0.1,^{*}\ p<0.05,^{**}\ p<.01,^{***}\ p<.001\right)$; checkmarks indicate the inclusion of fixed effects.

inventors employed by a sector was associated with a highly significant increase of 3.6 litigation cases per 1000 patents. This compares to the average increase of 1.33 litigations per 1000 patents observed over the period. Alternatively, a one standard deviation increase in the share of inventors (3pp) raises litigations per 1000 patents by 11.8, which corresponds to 0.5 standard deviations. The coefficients are virtually unchanged when size controls are included, outliers are dropped as above, or increases in inventor shares are lagged to mitigate concerns of reverse causality (results are available upon request).

This last set of results further supports the hypothesis that defensive innovation increased in concentrating sectors. To protect their dominant position, firms engage in such R&D to thwart innovation by potential competitors, which manifests through an increase in patent enforcement cases and a reduction in inventors' productivity in sectors with increased concentration.

1.2.6 Alternative Channels

The above empirical analysis shows that inventors have accrued to sectors with increased concentration, accruing primarily to incumbent firms, and leading to an increase in litigation, a fall in inventors' productivity and forward citations. My interpretation of these empirical findings is that firms have increased their efforts in defensive innovation, meant to secure patents that can later be used to discourage further entry. As noted in the literature section, several other papers have described mechanisms that could lead to increased concentration of inventors at the top of the firm distribution and decreased R&D productivity. Two main competing explanations stand out.

A first explanation concerns potential decreasing returns to innovation in the spirit of **?**. I acknowledge that R&D might in general have become more difficult, but my results do not show a decrease in patents per inventor in sectors with increased concentration. On the contrary, given that my inventor measure captures patent per capita, I effectively observe a relative increase in patenting activity in high-concentration sector, excluding that "ideas getting harder to find" is the main channel driving my results.

Another channel that could explain my results is an increase in incremental and firm-specific research documented by **??**. I verify that sectors with increased concentration did not see increased self-citations or falls in patent generality, which are commonly used measures of the radical nature and applicability of patents.[8] While incremental innovation certainly contributes to aggregate R&D productivity trends, it does not appear to be a driving force behind my findings, which therefore document an independent channel contributing to lowered inventors' productivity.

[8] See Appendix **??**.