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Recombination of ideas and the direction of inventive activity in economic growth research: Evidence from the Journal of Economic Growth

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Abstract

We explore the inventive activity and recombinant ideas in the field of economic growth research by analyzing the Journal of Economic Literature (JEL) classification codes assigned to articles published in the Journal of Economic Growth. The average number of JEL codes, authors, keywords, pages and references per article have increased over time, consistent with the increasingly complex idea combinations. Research is concentrated around specific JEL codes (O4 and O1), but the concentration has decreased, suggesting an increasing variety of field-crossing idea combinations. We observe a negative association between the number of JEL codes and received citations. Moreover, having no JEL code from the O class is negatively associated with received citations. The findings suggest that, on average, articles combining ideas from more than two fields and articles focusing on atypical topics are less likely to become influential.

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1 Introduction

Inventions are based on the recombination of ideas into new ones; this is at the heart of technological progress, which is the main driver of economic growth in the long run. We explore the allocation of attention and direction of inventive activity in the *Journal of Economic Growth*. The novelty of this research is that we rely on *JEL* codes assigned by authors to their articles when analyzing idea combinations of economic growth researchers. *JEL* codes are the *de facto* classification scheme in economics research (Cherrier 2017; Heikkilä 2022). Presumably, the accumulation of *JEL* codes in the *Journal of Economic Growth* provides an overview of how the direction of inventive activity has evolved in the field of economic growth.

Using classifications to measure the quality of ideas is not a novel idea: Scholars analyzing patent data generally utilize information of patent classifications assigned to inventions to proxy their quality (see, e.g., patent scope, Lerner 1994; generality of citing patents, Trajtenberg et al. 1997; seminality/novelty in recombination, Fleming 2001, Verhoeven et al. 2016). The recombination of existing ideas into new ones is also at the heart of economic growth theory, as technological progress and innovation activity rely on the accumulation and application of new ideas (Weitzman 1998; Olsson 2000). Inventive activity can be viewed as an evolutionary search process in an idea space where the combination of existing ideas and inventions is central (Olsson 2000; Fleming 2001; Arthur 2007). As the attention of researchers is scarce and time is limited, researchers need to choose between competing research topics and "idea" categories. While ideas can be described as "recipes" (Jones 2021a), here we focus more broadly on idea categories, namely *JEL* classes.

It has been documented that the number of *JEL* codes assigned to economics articles has increased over time (Card & DellaVigna 2013; Rath & Wohlrabe 2016), which may suggest that ideas, or idea combinations, are getting more complex. For instance, Rath and Wohlrabe (2016) analyzed more than 200,000 articles from the Research Papers in Economics (RePEc) repository and reported that the average number of *JEL* codes per paper increased from around 1.6 in 1991 to 3.0 in 2013. Moreover, they found that the number of *JEL* codes was positively associated with the number of authors, characters in the title and journal pages.

The simple research question of this paper is: "How have the recombination of ideas and the direction of inventive activity evolved in the *Journal of Economic Growth*?" The contribution of this paper is to apply methods from patent literature and *JEL* codes data to investigate the evolution of idea combinations in scholarly articles in the field of economics.

2 Data and method

We collected information on all the articles published in the *Journal of Economic Growth* between its founding year of 1996 and 2021. The journal is among the most influential economics journals.[1] Its submission guidelines instruct that "[a]n appropriate number of *JEL* codes should be provided," but there is no explicit minimum or maximum number of codes.[2]

[1] IDEAS/RePEc Simple Impact Factors for Journals, https://ideas.repec.org/top/top.journals.simple.html. Accessed 22 March 2022.
[2] https://www.springer.com/journal/10887/submission-guidelines. Accessed 22 March 2022.

The current *JEL* codes system is based on the 1990 revision that has evolved incrementally over time (Cherrier 2017) into a system comprising more than 850 three-digit categories.[3] Instead of reflecting specific ideas in the idea space (Olsson 2000), *JEL* codes describe high-level topics and list related keywords. There are different levels of *JEL* codes, one-digit (main), two-digit and three-digit, and the majority of existing studies has focused on the main classes (Rath & Wohlrabe 2016), or created their own classifications based on assigned *JEL* codes (Card & DellaVigna 2013). We assume that *JEL* codes are proxies for idea categories and simultaneously assigned *JEL* codes for idea combinations.

Our data consist of 347 articles, of which 327 (94%) contain information on *JEL* codes. Of the 1,097 assigned *JEL* codes, 948 (86.4%) are three-digit codes, 145 (13.2%) are two-digit codes and one paper had four four-digit codes. To avoid considering two-digit and four-digit codes as "distinct ideas" from three-digit *JEL* codes, we deleted redundant last zeros from four-digit codes and added zeros to two-digit codes to change them into comparable three-digit *JEL* codes. Adding a zero is reasonable, as the first subclasses of three-digit codes under each two-digit super-category are "General" classes, and presumably authors assigning two-digit codes indicate that the ideas of the paper relate at a general level to the topics in a two-digit category.[4] This manipulation led to no cases with duplicate *JEL* codes per article.

We analyzed: 1) what the frequently assigned *JEL* codes and *JEL* combinations are, 2) how the number of *JEL* codes and combinations per article have evolved, and 3) at what rate novel *JEL* codes and *JEL* code combinations are introduced and how concentrated they are. We measured concentration by calculating the annual share of the most frequent (concentration ratio, CR1) one-digit code and the three most frequent (CR3) two-digit *JEL* codes, as well as the Herfindahl-Hirschman index (HHI) of one-digit *JEL* codes.

Furthermore, we conducted regression analyses to examine how article characteristics are associated with the number of *JEL* codes, following Rath and Wohlrabe (2016), and how article characteristics are associated with received citations (Tahamtan et al. 2016). The explanatory variables are the number of keywords, authors, pages, references and title characters when the dependent variable is the number of *JEL* codes, and we estimated negative binomial regression models. Presumably, a higher number of keywords, authors, pages and references indicate potential for combinations of a larger number of ideas. Hence, we expected these variables to be positively associated with the number of assigned *JEL* codes and received citations (cf. Tahamtan et al. 2016).

When the dependent variable is the number of received citations, we added the following explanatory variables: the number of *JEL* codes and a binary variable indicating whether any of the *JEL* codes is from *JEL* code class "O: Economic Development, Innovation, Technological Change, and Growth." We applied negative binomial regression when the dependent variable is the number of citations and, alternatively, ordinary least squares regression when the dependent variable is the logarithm of citations. In all models, we controlled for cohort effects (i.e., the time window during which the articles have been citable) by including publication year dummies.

[3] https://www.aeaweb.org/econlit/jelCodes.php. Accessed 22 March 2022.

[4] For instance, this procedure led to changing 30 "O4: Economic Growth and Aggregate Productivity" *JEL* codes into "O40: Economic Growth and Aggregate Productivity: General." Using the originally assigned codes provides qualitatively and quantitatively similar results that are not reported.

3 Findings

Table 1 presents the descriptive statistics. The articles have on average 3.1 *JEL* codes and the median number of codes is 3, ranging between 1 and 13 (see Table A.1 in the Appendix). The most frequent *JEL* codes, *JEL* code pairs and keywords are also reported. Unsurprisingly, the top three JEL codes are O40: Economic Growth and Aggregate Productivity: General, O11: Macroeconomic Analyses of Economic Development, and O10: Economic Development: General. The most frequent combinations are all combinations including O40 while "Growth," "Economic growth" and "Human capital" are the top keywords.

Figure 1.A presents the evolution of article characteristics. Consistent with previous studies (Card & DellaVigna 2013; Rath & Wohlrabe 2016), we observe that the average number of *JEL* codes has increased over time, from 2.8 in 1996 to 4.5 in 2021. Concurrently, the average number of keywords has increased from fewer than four to more than five. The average number of authors has also increased in line with the general trend in economics (Jones 2021b). The number of pages has slightly increased, but the average number of references has approximately doubled, from about 35 to about 70. This illustrates how researchers "stand on the shoulders of giants" and build upon the accumulating amount of research increasingly accessible online. The concentration measures (CR1, CR3 and HHI) in Figure 2.B indicate that the concentration of *JEL* codes and combinations have reduced and the variety of ideas has increased in the 2010s. Figure 2.C presents the number and share of previously unobserved "new" *JEL* codes by year, and Figure 2.D presents the same trends for *JEL* combinations. These suggest increases in the absolute number of *JEL* codes and combinations, and a convergence to a relatively constant annual share of new *JEL* codes (ca. 20%) and *JEL* combinations (ca. 70%). The increasing number of new *JEL* combinations seem to suggest an increasing variety of research trajectories.

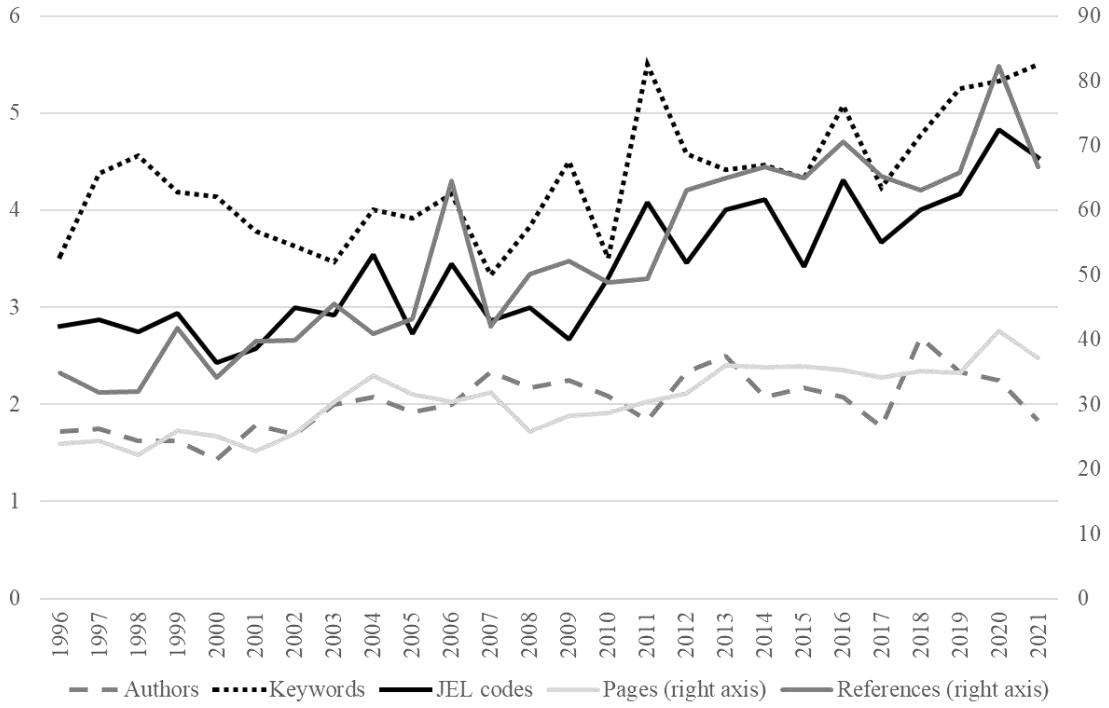
Table 1. Descriptive statistics

Number of articles	347
Top3 JEL codes*	
	1. O40 (113)
	2. O11 (58)
	3. O10 (54)
Top3 JEL codes combinations*	
	1. O10, O40 (17)
	2. O30, O40 (16)
	3. O31, O40 (13)
Top3 Keywords	
	1. Growth (77)
	2. Economic Growth (50)
	3. Human Capital (42)
Distribution of JEL codes	
A General Economics and Teaching	0.09 %
C Mathematical and Quantitative Methods	3.65 %
D Microeconomics	6.02 %
E Macroeconomics and Monetary Economics	6.29 %
F International Economics	4.92 %
G Financial Economics	0.91 %
H Public Economics	2.37 %
I Health, Education, and Welfare	3.92 %
J Labor and Demographic Economics	9.66 %
K Law and Economics	0.18 %
L Industrial Organization	2.19 %
M Business Administration and Business Economics • Marketing • Accounting • Personnel Economics	0.27 %
N Economic History	7.57 %
O Economic Development, Innovation, Technological Change, and Growth	45.76 %
P Economic Systems	1.37 %
Q Agricultural and Natural Resource Economics • Environmental and Ecological Economics	0.91 %
R Urban, Rural, Regional, Real Estate, and Transportation Economics	1.64 %
Z Other Special Topics	2.28 %
Concentration of JEL codes, annual averages	
CR1 1-digit	0.458
CR3 1-digit	0.630
CR1 2-digit	0.171
CR3 2-digit	0.429
HHI 1-digit	2760.446
Averages per article	
JEL codes**	3.355
Keywords	4.291
Authors	1.986
Title characters	58.625
Pages	30.233
References	51.199

Notes: Information collected from Scopus on 24 Mar 2022. *0 added to 2-digit JEL codes. **20 Articles with no JEL codes excluded. Notes: CR1 (CR3) 1-digit: The share of the (three) most frequent JEL code(s) of all assigned JEL codes at 1-digit JEL code level (e.g., “O”). CR 1 (CR3) 2-digit: The share of the (three) most frequent JEL code(s) of all assigned JEL codes at 2-digit JEL code level (e.g., “O4”). HH1 1-digit: Herfindahl-Hirschman Index of JEL codes at 1-digit JEL code level.

Figure 1. Trends in article characteristics and JEL codes

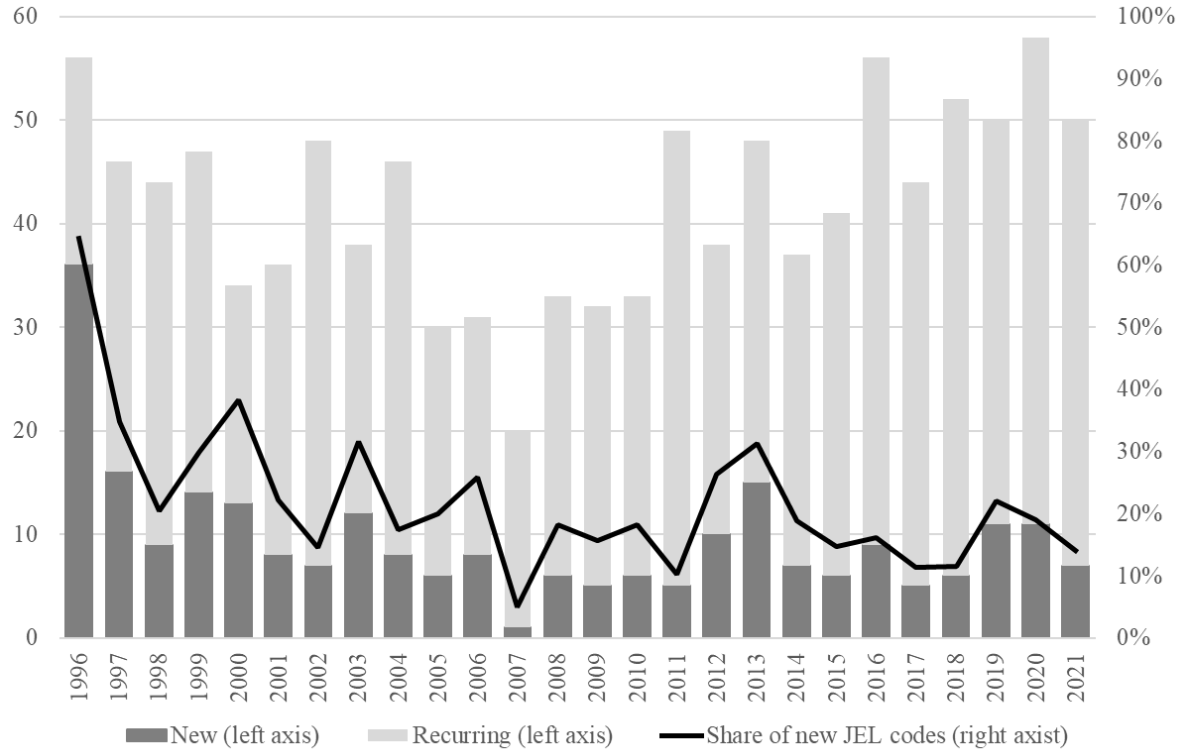
A. Article characteristics



B. Concentration of JEL codes

Notes: CR1 1-digit: The share of the most frequent JEL code of all assigned JEL codes at 1-digit JEL code level (e.g., "O"). CR3 2-digit: The share of the three most frequent JEL codes of all assigned JEL codes at 2-digit JEL code level (e.g., "O4"). HH1 1-digit: Herfindahl-Hirschman Index of JEL codes at 1-digit JEL code level.

C. New and recurring JEL codes



D. New and recurring JEL code combinations

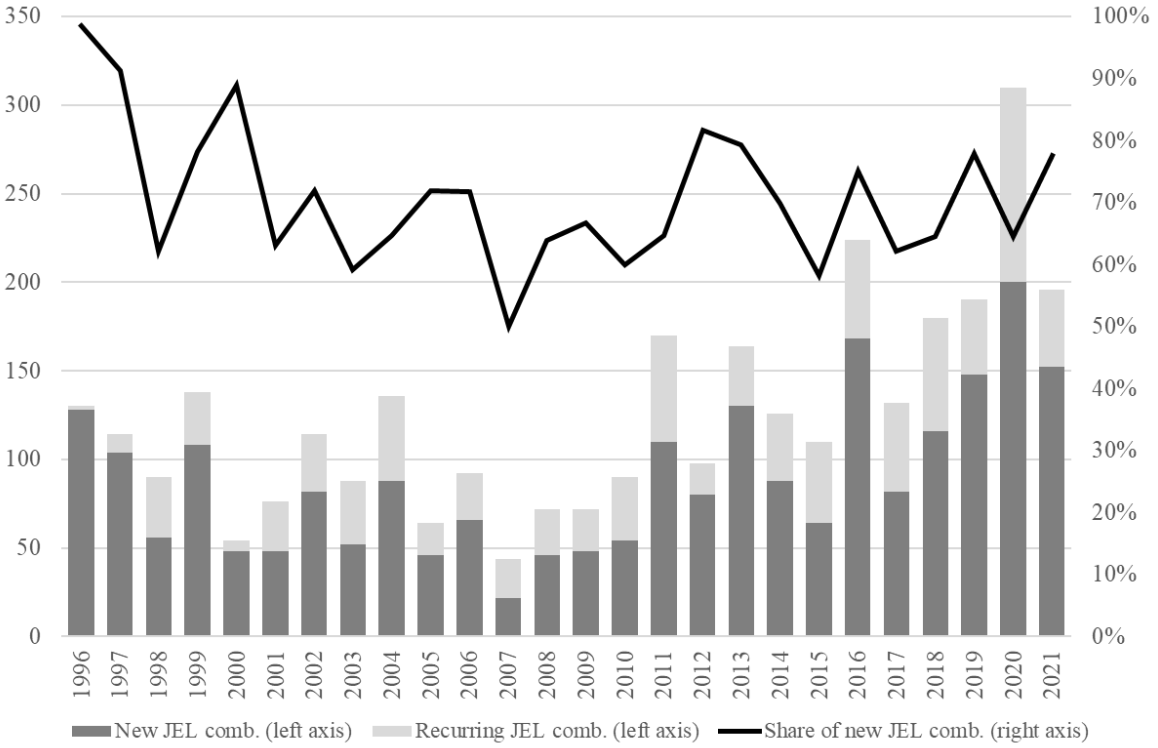


Table 2 reports the regression results. Model 1 shows that the number of keywords is positively associated with the number of *JEL* codes, in line with Rath and Wohlrabe (2016), but we do not observe statistically significant associations in the case of references, pages and title characters. There is a weak negative association between the number of authors and the number of *JEL* codes. We consistently observe a negative association between the number of *JEL* codes and received citations, suggesting that, on average, articles combining ideas from multiple fields are less likely to become influential. Interestingly, having no class O *JEL* code is negatively associated with citations, suggesting that articles on atypical topics are less likely to become influential.

Table 2. Regression results

	(1)	(2)	(3)	(4)	(5)
Model	Negative binomial	Negative binomial	Negative binomial	OLS	OLS
Dependent variable	Number of JEL codes	Citations	Citations	log(Citations+1)	log(Citations+1)
JEL codes		-0.108*	-0.128**	-0.048	-0.069
		(0.055)	(0.055)	(0.050)	(0.051)
No O class			-0.624***		-0.484**
			(0.191)		(0.213)
Keywords	0.088***	0.032	0.032	-0.014	-0.005
	(0.018)	(0.048)	(0.048)	(0.037)	(0.038)
Authors	-0.043*	0.302***	0.303***	0.372***	0.369***
	(0.023)	(0.069)	(0.067)	(0.079)	(0.077)
Pages	0.002	0.030***	0.031***	0.023***	0.024***
	(0.003)	(0.011)	(0.011)	(0.008)	(0.008)
References	0.001	0.006*	0.008**	0.008***	0.008***
	(0.001)	(0.003)	(0.004)	(0.003)	(0.003)
Title characters	0.001	-0.003			
	(0.003)	(0.003)			
Constant	0.676***	4.237***	4.257***	3.759***	3.789***
	(0.136)	(0.414)	(0.408)	(0.412)	(0.396)
Year fixed effects	X	X	X	X	X
Pseudo R2	0.057	0.080	0.082		
R2				0.516	0.525
Log-likelihood	-557.070	-1666.994	-1663.487		
Observations	327	327	327	327	327

Notes: 20 Articles with no assigned JEL codes excluded. Robust standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. Information collected from Scopus on 24 Mar 2022

4 Conclusions

We analyzed the *JEL* codes of articles published in the *Journal of Economic Growth* between 1996 and 2021. The average number of *JEL* codes, authors, keywords, pages and references per article have increased over time, consistent with increasingly complex idea combinations. Research is

concentrated around specific *JEL* codes (O4 and O1). The concentration measures of *JEL* codes and the increasing number of *JEL* combinations indicate an increasing variety of idea combinations. We observe a negative association between the number of *JEL* codes and received citations, and that having no *JEL* code from the O class is negatively associated with received citations. The findings suggest that, on average, articles combining ideas from more than two fields and articles focusing on atypical topics are less likely to become influential.

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Appendix

Table A.1. Descriptive statistics

Variable	N	Mean	SD	Median	Min	Max
JEL codes	327	3.161	1.615	3	0	13
Keywords	347	4.291	1.592	4	0	14
Authors	347	1.986	0.865	2	1	5
Title characters	347	58.625	23.998	57	16	161
Pages	347	30.233	9.095	29	4	59
References	347	51.199	24.196	46	8	173
Citations*	347	114.496	254.555	35	0	2472

Correlation matrix

	JEL codes	Keywords	Authors	Title characters	Pages	References	Citations
JEL codes	1						
Keywords	0.458***	1					
Authors	0.029	0.032	1				
Title characters	0.107	0.108**	0.036	1			
Pages	0.317***	0.249***	0.195***	0.105	1		
References	0.350***	0.313***	0.075	0.194***	0.564***	1	
Citations*	-0.160***	-0.080	0.166***	-0.139***	0.011	-0.112**	1

Notes: *Information collected from Scopus on 24 Mar 2022.