End of Middle-Classes? Social Inequalities in Digital Age

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Abstract

In the recent discussion about the future of modern capitalist societies many well-thought speculations rely on the interplay between continued processes of globalization, increased trends of so-called digitalization and other forms of technological progress and their effects on the system of organizations and occupations. In the sociology of change and political conflict, middle classes have always held a central function. Middle classes serve as a kind of conflict buffer of modern societies. According to Collins (2013), technological displacement of middle-class labour is not much more than twenty years old; while it took almost 200 years to destroy the working-class labour force, computerization of middle-class labour (since the last decade of the 20th century) is proceeding at a much faster pace than the mechanization of the manual labour force (which took approximately the entire 19th century and three-quarters of the 20th) (Collins 2013, 56). The topic is closely connected to discussion in evolutionary economics as provided by Schumpeter's (2000) idea of "creative destruction" which is led by the assumption of a fragile balance between births and deaths of firms, jobs, occupations, and economic sectors in the course of economic development. Of course, there is already some lively discussion on automation and digitalization as such, but less research focusses explicitly at the middle classes.

The paper tries to test Collins' thesis of an increased de-middledization by international comparative data provided by Eurostat for the period from 2003 to 2014. Firstly, we examine the size of the middle class and the changes within the time period based on the European Union Statistics on Income and Living Conditions (EU-SILC) dataset. We find the evidence of a negative link between digitalization and the size of the middle class, but the result is highly sensitive to the definition of middle class as the dependent variable. As suggested by Piketty (2014), the term of middle class is debatable because it does not have any single definition. The most consistent effect is shown when we define the middle class as the share of households whose incomes are between 60 percent and 150 percent median.

While there appears to be only limited effect of ICT contribution on GDP and total employment on the size of the middle class, the evidence is highly significant in the effect of innovation in digital sector as measured by ICT-related patents on the size of the middle class. One explanation for this might be ICT-related innovation is benefited not only by those in ICT sectors, but also the wide array of occupations. Therefore, approaching digitalization indicator by the contribution of ICT sector to the GDP and total employment could be misleading. With this paper, we have provided only the first test of the relationship between digitalization and the size of the middle class.

1. Introduction

The paper is about a socioeconomics and sociology of middle classes in a theoretical discussion and empirically focussing at "middle class" segments of different European societies for the time period between 2003 and 2014. The argumentation is strongly embedded to Schumpeterian thought of evolutionary economics but it is tried to link discussion about "creative destruction" to digitalization and the evolution of stratified societies in Europe on international comparison. The paper attempts to question assumptions of growing inequality theoretically and empirically by referring to Collins' thesis of an increased de-middledization. We argue that the ability of ICT innovations (*i.e.* digitalization) to perform specialized, routine, and predicted tasks better than human allows them to supress middle skilled labor, affect to the polarization of jobs, and finally lead to de-middledization.

2. Schumpeter: Creative Destruction

Creative Destruction is the famous but ambivalent term, which was originated by Joseph A. Schumpeter (1883 – 1950), an Austrian economist who had professorships in Austria and Germany before joining the faculty at Harvard University in the early 1930s where he spent the rest of his career. The term refers to the economic processes by which old systems, technology, innovation, and thinking is destroyed by new ones. Schumpeter saw creative destruction as a logical by product of capitalism, but not necessarily as a good thing.

From a contemporary perspective, Schumpeter was truly interdisciplinary and his many works span fields such as sociology, finance economics, and politics (Bögenhold 2014). Over a time span of nearly fifty years, Schumpeter published numerous articles and books. "Creative Destruction" serves as a title of a chapter in the book "*Capitalism, Socialism, and Democracy*" (2000 [1942]) in which he deals with the modus operandi of competition. Schumpeter argues against some predominant economic thought at his time, which was characterized as being static. In opposition to that, Schumpeter conceptualized economy being in a constant flux of economic and social change. Schumpeter frequently discussed the parallels and divergences of his thought and Marxism: "The essential point to grasp is that in dealing with capitalism we are dealing with an evolutionary process. It may seem strange that anyone can fail to see so obvious a fact which moreover was long ago emphasized by Karl Marx" (Schumpeter 2000, p. 82).

Schumpeter is regarded as one of the pioneers of "evolutionary economics". He viewed capitalism as a "form or method of economic change" (Schumpeter 2000, p. 82). Creative destruction is a contradictory expression, which seeks to highlight the fact that competition and inherent processes towards monopolistic and oligopolistic competition are only one part of the overall economic game. Too often neglected are simultaneous processes of the creation of new firms, new ideas, and even new business leaders elsewhere in an economy. Deaths and births —both of business enterprises and individuals— are two sides of the same coin, and Schumpeter dubbed creative destruction as an essential fact about capitalism.

Creative destruction has to be seen in a wider context of innovation and entrepreneurship for which Schumpeter is well-known. Entrepreneurs are treated as agents to introduce new inputs into the economy. He defined an entrepreneur as a person who comes up with "new combinations" (new goods, new methods of production, new markets, new sources of supply, new organizations of any industry or combinations between these items) which are commonly called "innovation." Entrepreneurs are driven by a set of diverse motivations and their activity is fundamental for economic development. Innovation is the steady new "fresh blood" through new ideas and people who keep the "capitalist machine" going. However, creativity is always combined with destruction elsewhere. When new products appear, consumer demands change, and existing production and related markets are rendered obsolete. In some cases, entire communities are negatively impacted when the production of new products locates elsewhere (Bögenhold 2010, 2013).

3. Creative Destruction and the Future of Capitalism

Capitalism exists always as a development with a fragile balance of "coming" and "going" of firms, entrepreneurs, goods, ideas, mentalities, and ideologies. Although Schumpeter is often regarded as academic hero of entrepreneurship and innovation, he was highly sceptical about the endogen creativity of capitalism to achieve a balance between creativity and destruction. In one chapter he posed the question "Can capitalism survive?" and he did not hesitate to answer "No, in my opinion not". He actually felt that socialism would eventually supplant capitalism. So far, Schumpeter can be said to have underestimated the potential innovation sources of capitalism.

Despite those very general conclusions about the destiny of capitalism, other voices argue that processes of creative destruction will affect the system of social stratification in modern societies. According to Collins (2013), technological displacement of middle-class labour is not much more than twenty years old whereas it took almost 200 years to destroy the working-class labour force. Therefore, none of the previous ways to compensate job losses will work effectively anymore in the future. Now, the twenty-first century trajectory of technological development is likely to push the middle classes into redundancy.

Within recent discussion about the future of modern capitalist societies many well-thought speculations rely on the interplay between continued processes of globalization, increased trends of so-called digitalization and other forms of technological progress and their effects on the system of social stratification and social mobility (Wallerstein et al. 2013). Middle classes serve as a kind of conflict buffer of modern societies. In his discussion why there is no socialism in the United Stated which was questioned in book format by Werner Sombart in 1906 (see Sombart 1976), the upcoming middle classes and their related relative wealth played a central role. Sombart argued that if people earn means to engage in different consumption activities they start to arrange positively with a political-economic system receiving a status, which is worth defending. With roast beef and apple pie all socialist dreams disappear, was somehow the answer by Sombart (1976) to the stability of capitalism in early 20th century.

This paper is about a socioeconomics and sociology of middle classes in a theoretical discussion and empirically focussing at the segment of middle classes. The argumentation gets started by discussion about "creative destruction" and its appearance in context to digitalization and the evolution of stratified societies in Europe. Collins' thesis of an increased de-middledization shall be taken up as a hypothesis which must be confronted with empirical evidence in order to arrive at some better informed insights into growing inequality theoretically, empirically and internationally and its impact digitalization. Of course, the research is also rooted by recent social stratification research that has turned towards questions of inequality as research proxy. The current enormous success story of Piketty's "Capital in the 21st Century" (Piketty, 2014) by members of the economics and sociology communities is a demonstration of the ongoing attraction of questions about (in)equality and stratification (Boushey et al. 2017, King 2017).

4. Creative Destruction and Jobs

Academic observers have almost focused at the assumed negative consequences of economic development and described them as warnings. Fear of deserted factory halls go back already to the 1960th when an article in *Time Magazine* argued already this way:

> "The number of jobs lost to more efficient machines is only part of the problem. What worries many job experts more is that automation may prevent the economy from creating enough new jobs. . . . Throughout industry, the trend has been to bigger production with a smaller work force. . . . Many of the losses in factory jobs have been countered by an increase in the service industries or in office jobs. But automation is beginning to move in and eliminate office jobs too. ... In the past, new industries hired far more people than those they put out of business. But this is not true of many of today's new industries. . . . Today's new industries have comparatively few jobs for the unskilled or semiskilled, just the class of workers whose jobs are being eliminated by automation" (*Time Magazine,* 1991).

Recent developments in context with robots and artificial intelligences have multiplied those earlier worries. The book "*The Second Machine Age*" (Brynjolfsson & McAfee 2014, p. 11):

> "Rapid and accelerating digitization is likely to bring economic rather than environmental disruption, stemming from the fact that as computers get more powerful, companies have less need for some kinds of workers. Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead. As we'll demonstrate, there's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rat".

Those fears neglect that sides of destruction are always in parallel with areas of creativity at the same time which lead to the evolution of new tasks and job profiles in different other areas. While Randall Collins (2013) is almost pessimistic in his perceived evaluation in context with the process of increased digitalization, which lead to a "stretching" of inequality, David Autor (2011, 2014, and 2015) regards positive potentials. It is a tricky research endeavour to investigate the interplay of "Artificial Intelligence, Automation and Work" (Acemoglu and Restrepo 2018). Research needs concrete empirical data to get instruction which position is more adequate than another. We know also that digitalization goes along with sustainable changes of occupations and their contents where new competencies will be fostered (Yoo et al, 2012), especially with mathematical skills and thought in cross disciplinary thought, creativity and languages (Deming 2015). Research for positive and negative impacts of the digitalization process on inequality and the persistence of the middle classes is an eminent important task. Our research is about the question of "stretching". Will stratified societies turn its middle tentatively from convex to concave curves?

5. Empirical analysis

5.1 The Model and Dataset

We conduct an empirical analysis to test the hypothesis that digitalization leads to the shrinking size of the middle class with EU countries as the unit of analysis. The dataset covers the unbalance panel data for the period 2003-2014 (12 years) consisting of 31 group of observations. The 28 of them are the members of EU and the rest are Switzerland, Iceland, and Norway. The data are obtained from Eurostat database.

A series of panel regressions are presented to investigate the relationship between a variety of digitalization measurements and the size of the middle class in European countries. The basic model is as follows

$$Middle\_class_{it} = \propto +\beta_1\ digitalization_{i(t-h)} + \beta_2\ EduHigh_{it} + \beta_3\ EduLow_{it} + \beta_4\ GovExp_{it} + \beta_5\ Openness_{it} + \beta_6\ GDPpcap_{it} + \beta_7\ Popgrowth_{it} + \beta_8\ Unemployment_{it} + v_i + \varepsilon_{it}$$

where *Middle_class* represents dependent variable, a series measures of the size of the middle class in a country while *digitalization* stands for one group of digitalization measures as independent variables. The rest are control variables: *EduHigh* and *EduLow* are the proportion of high educated and low educated labor respectively, *GovExp* stands for government expenditure as percentage to GDP and *Openness* is trade openness index as measure for globalization. GDP per capita, population growth, and the rate of unemployment are also included in the model. Meanwhile, $\propto$ is constant, β_n is coefficient for each variable, and *v* and ε are unobserved country/region specific characteristics which are time-invariant effects and idiosyncratic error terms, respectively. The model shows the presence of subscript time lag *h* in the independent variables. The use of lagged independent variable is a common strategy to confront simultaneously problem. It also clarifies that the independent variable needs a delay in giving an impact to the explained phenomenon.

The nature of a static panel data requires us to choose between fixed effects or random effects model. The Hausman test can be used to test the correlation between idiosyncratic errors and the independent variables. If the correlation is there, the fixed effect model is the appropriate method of estimation. In our case the null hypothesis of Hausman test is rejected. It suggests that fixed effects model fits better rather than random effects model. Theoretically, fixed effect model is relevant in this case because it controls the unobserved time-invariant country heterogeneity and thus it is in line with the assumption of path-dependence in evolutionary economic field.

5.2 Dependent Variables

Surprisingly, there is no single definition about middle class among scholars (Pressman, 2015). For a long period of time, distributional studies have focused on the poor and the rich while those in the middle are forgotten (Atkinson and Brandolini, 2011). The concern to define and measure the middle class has been increasing in the past decade since the issue of shrinking middle class became a major anxiety. Therefore, since there is no consensus, any attempts to define the size of the middle class are *"quite obviously arbitrary and open to challenge"* (Piketty, 2014).

In this study, we focus on the disposable household income range which is measured by the survey of European Union Statistics on Income and Living Conditions (EU-SILC) provided in Eurostat database. We use two approaches in defining the size of the middle class as our dependent variable. Firstly, our measure of the middle class starts from the median household income. The middle classes are defined as those whose income lies between an absolute lower cut-off and upper cut-off near the median. PEW Research Center (2012) firstly defines middle-class in US to be between 67 percent and 200 percent of the median income.

However, we think there is no exact number of both lower and upper cut-off point because it depends on the context of the study. We follow the argument from Ravallion (2010) and Atkinson and Brandolini (2011) which state that the lower cut-off of the middle class is equivalent with the line threshold of at-risk-of poverty. In other words, those who are classified as middle class are those who do not have any risk of poverty. In the EU, at-risk-of poverty threshold is set at 60 percent of the national median household income. Thus, we choose that number to set the lower cut-off for defining the middle class. Meanwhile, the upper cut-off distinguishes the middle class and the rich. We set the 150 percent of the median as the upper cut-off for defining the middle class as also suggested by Grabka and Frick (2008) to measure the size of German middle class. To sum up, this study defines the middle class as the population group with a relative income position between 60 and 150 percent of the median.

Secondly, we look at the fraction of income received by the middle 60 percent of earners which was firstly defined as middle class by a Nobel Laurate economist, Robert Solow (Atkinson and Brandolini, 2011). It is regarded as the middle three income quintiles between the top quintile of 20 percent of the richest and the bottom quintile of 20 percent of the poorest. As the robustness check, we also consider a less size of middle class by limiting the size to the middle 40 percent of earners. For each country, Eurostat provides household income per decile of distribution. Thus, we can calculate the income share of both the middle 40 percent and 60 percent of earners. While the first approach focuses on *the share of the population*, this second approach emphasizes *the share of income in the population*.

Table 1 and Table 2 capture the size of the middle class in EU countries measured by the first and second approaches respectively. The correlation between the first and second approach of middle class measurement is 0.76. The de-middledization phenomenon in the current decade can be shown obviously, when the middle class is defined by the first approach: middle classes are those between 60 percent and 150 percent of median household income. As can be seen in Table 1, 20 out of 31 EU countries experience the declining of the middle class in the period of 2003-2014. The highest de-middledization phenomenon are experienced by Germany (-9.3 percent decline), Sweden (-6.4 percent), and Spain (-6 percent) respectively. Interestingly, despite of the shringking phenomenon, in all of Scandinavian countries and the Netherlands, the size of the middle class are greater than 70 percent of the population. It suggests that those countries tend to be more equal with regards to the distribution of income.

Table 1: Population share of the bottom, middle, and top income groups in EU countries 2003-2014

Country	First observation (2003-2007)			Last observation (2014)			Size of Middle Class
	Poor below 60%	Middle Class 60%-150%	Rich Above 150%	Poor below 60%	Middle Class 60%-150%	Rich Above 150%	
Belgium	15.4	67.5	18.2	15.5	68	17.1	Increase
Bulgaria	18.4	56.6	21.4	21.8	55	23	Decrease
Czech Republic	10.4	72.3	17.8	9.7	74.2	16.1	Increase
Denmark	11.7	76.7	12.4	12.1	72	15.8	Decrease
Germany	12.2	71.7	15.8	16.7	62.4	20.9	Decrease
Estonia	20.2	55.1	26.6	21.8	51.2	27.2	Decrease
Ireland	20.5	58.9	20.2	16.4	60.9	22.8	Increase
Greece	20.7	56.2	23.9	22.1	55.9	22.7	Decrease
Spain	20.1	58.7	21.2	22.2	52.7	25.2	Decrease
France	13.5	67.8	19.2	13.3	68.7	17.7	Increase
Croatia	20.6	56.4	25	19.4	58.5	21.5	Increase
Italy	18.9	59.3	21.5	19.4	59.1	21	Decrease
Cyprus	16.1	63.5	20.9	14.4	60.2	23.6	Decrease
Latvia	19.4	51.1	25.4	21.2	51.7	25.8	Increase
Lithuania	20.5	53.6	26.4	19.1	52	25.8	Decrease
Luxembourg	11.9	68.2	19.1	16.4	64.2	20.5	Decrease
Hungary	13.5	67.2	16.9	15	66.6	18.5	Decrease
Malta	14.3	65.1	20.7	15.9	65.2	18.5	Increase
Netherlands	10.7	73.8	16.5	11.6	71.9	16.5	Decrease
Austria	13.2	69.1	17.9	14.1	68.6	17.5	Decrease
Poland	20.5	57.1	23.8	17	61.1	21.3	Increase
Portugal	20.4	55.3	25.3	19.5	56.5	24	Increase
Romania	24.6	51.4	25	25.1	49.6	25	Decrease
Slovenia	12.2	73.4	15	14.5	69.9	15.8	Decrease
Slovakia	13.3	72.2	16.2	12.6	71.8	15.9	Decrease
Finland	11	73.1	15.2	12.8	71.3	16.3	Decrease
Sweden	11.3	76.8	13.7	15.1	70.4	15.1	Decrease
United Kingdom	19	57.6	23.4	16.8	60.2	23.2	Increase
Iceland	10	76.5	13.8	7.9	76.5	13.9	Decrease
Norway	10.8	77	12.2	10.9	75.1	13	Decrease
Switzerland	15	64.3	20	13.8	64.9	19.5	Increase

Source: Author's calculations from Eurostat database

Table 2: Income share of the bottom, middle, and top income groups in EU countries 2003-2014

Country	First observation (2003-2007)			Last observation (2013-2014)			Size of Middle Class
	Poor bottom 20%	Middle Class 60%	Rich top 20%	Poor bottom 20%	Middle Class 60%	Rich top 20%	
Belgium	8.5	54.9	36.6	9.2	56.0	34.8	Increase
Bulgaria	7.5	53.7	38.8	6.2	51.8	42.0	Decrease
Czech Rep.	9.8	54.2	36.0	10.1	54.2	35.7	Decrease
Denmark	9.7	55.9	34.4	8.9	54.5	36.6	Decrease
Germany	9.5	54.6	35.9	7.4	54.3	38.3	Decrease
Estonia	6.1	49.9	44.0	6.4	51.5	42.1	Increase
Ireland	7.8	53.9	38.3	8.1	52.7	39.2	Decrease
Greece	6.5	52.1	41.4	6.5	52.5	41.0	Increase
Spain	7.3	54.3	38.4	5.9	53.4	40.7	Decrease
France	9.0	53.5	37.5	9.1	52.4	38.5	Decrease
Croatia	7.0	54.3	38.7	7.3	55.2	37.5	Increase
Italy	7.2	52.6	40.2	6.8	53.9	39.3	Increase
Cyprus	8.6	53.9	37.5	8.0	48.9	43.1	Decrease
Latvia	6.4	50.7	42.9	6.5	51.2	42.3	Increase
Lithuania	6.2	50.7	43.1	6.9	51.0	42.1	Increase
Luxembourg	9.2	53.6	37.2	8.3	54.7	37.0	Increase
Hungary	9.2	53.8	37.0	8.8	53.7	37.5	Decrease
Malta	9.2	54.9	35.9	9.1	54.1	36.8	Decrease
Netherlands	9.1	54.9	36.0	9.3	55.1	35.6	Increase
Austria	9.0	54.3	36.7	9.0	54.3	36.7	Decrease
Poland	6.4	51.3	42.3	7.9	53.2	38.9	Increase
Portugal	6.3	48.6	45.1	6.7	51.6	41.7	Increase
Romania	5.4	50.5	44.1	5.8	53.8	40.4	Increase
Slovenia	9.9	56.3	33.8	9.2	56.3	34.5	Decrease
Slovakia	9.0	55.5	35.5	9.1	55.4	35.5	Decrease
Finland	10.0	54.5	35.5	9.7	55.0	35.3	Increase
Sweden	9.8	57.3	32.9	8.8	56.8	34.4	Decrease
United Kingdom	7.1	50.9	42.0	7.7	53.0	39.3	Increase
Iceland	10.1	55.5	34.4	10.6	55.8	33.6	Increase
Norway	9.7	53.7	36.6	9.9	56.5	33.6	Increase
Switzerland	8.2	52.9	38.9	8.6	52.9	38.5	Decrease

Source: Author’s calculations from Eurostat database

5.3 Independent Variables

The term of digital economy which was introduced by Tapscott's book in 1996 refers to an economic system where the use of ICT is widely spread (Kotarba, 2017). Since then, measuring the digital economy is popular among scholars and even policy regulators. OECD (2014), for instance, has identified a comprehensive set of indicators for comparisons between countries in term of their digital economies. Mueller *et al* (2017) found at least 11 cross-country studies between 2013 and 2015 which attempt to measure the digital economy. Some of those indicators are R&D spending in ICT, labor productivity in ICT related sector, value added of ICT related sector, ICT investment and infrastructure, ICT related sector revenue and its share to GDP, and number of patents in ICT related sector as the measurement of innovation in digital economy. Some of them even propose the ICT composite index which combines the numerous ICT variables (for instance OECD, 2014; Katz and Koutroumpis, 2013; and International Telecommunication Union, 2014).

In this study we limit the digitalization indicators into three main measurements which are: innovation output, economic, and employment indicators. Hypothetically, those three indicators have the potential possibility to link with income distribution and the size of the middle class. The first indicator is ICT-related patent as the proxy of innovation in ICT sectors. This study uses European Patent Office (EPO) patent applications per million of total population as provided by Eurostat. Despite of its drawback, patent is regarded as an outcome of a successful innovation process. For the use of cross country comparison, patent statistics are unique since they provide the long historical time series (Cantwell & Vertova, 2004) and roughly comparable between the unit of analysis. ICT-related patents consist of five fields based on selected IPC codes including telecommunications, consumer electronics, computers, office machinery, and other ICT-related technologies.

The second indicator to measure digitalization is the share of ICT sector in GDP. To deal with the size of GDP, we multiply the *percentage of ICT sector in GDP* with *GDP per capita*. Thus, the product represents the size of revenue in ICT sectors per total population of the country. The definition of the ICT sector is based on NACE Rev. 2 classification which consists of ICT manufacturing and ICT services. Lastly, we use the ICT employment as share of total employment as the third indicator of digitalization. It represents how the emerging of ICT sectors is able to create new job opportunities.

5.4 Control Variables

Several control variables are included in the model to consider the presence of other potential explanatory variables associated with the size of the middle class. First of all, GDP per capita is included as the common control for the level of economic of countries. We use current prices of GDP per capita adjusted by purchasing power parities in euro currencies as provided by the Eurostat. Additionally, population growth, representing the density of a region, is also included in the model. Many studies link population growth with the distribution of income in two directions (for instance Winegarden, 1978).

We then incorporate government spending in controlling the model as the measure of government power to maintain the size of the middle class through the redistributive spending. Thus, we expect the positive correlation between them. The next control variable is trade openness which is defined as the ratio of total trade (*i.e.* export plus import) to GDP. Trade openness ratio may be seen as an indicator of the degree of globalisation. Both variables are gathered from PENN World Table.

Educational attainment levels are also included to reflect the distribution of human capital among the working population. Given by Eurostat, high educated people are defined as those adult population who reach tertiary education level (levels 5 to 8) whereas low educated people are those adult population whose education level is less than secondary level of education (levels 0 to 2). Finally, we include unemployment rate as the control variable considering the link between the degrees of unemployment with the shrinking size of the middle class. Due to the unemployment, a worker in a middle class group could move down to the lower level of economic status. To sum up, all of the variables included in the model are demonstrated in Table 3.

Table 3: List of variables

Variable Names	Description	Source
	Measure of middle class (Dependent Variables)	
Middle_class	Share of household having income between 60% and 150% of Median	Eurostat
Mid60	Share of income of household between decile 30 and 80 compare to total income of population	Eurostat
Mid40	Share of income of household between decile 40 and 70 compare to total income of population	Eurostat
	Measure of digitalization (Independent Variables)	
Patent_ICT_pop	The number of patent application to the EPO per million population for information and communication technology (ICT) manufacturing and services	Eurostat
ICT_GDP	Share of ICT sector to GDP multiplied by GDP per Capita	Eurostat
ICT_employee	Share of people working in the Information and Communication Technology (ICT) sector compare to total employment	Eurostat
	Control Variables	
GDPpcap	Real GDP per capita in Euro adjusted by Purchasing Power Parity	Eurostat
Popgrowth	Growth of total population	Eurostat
Gov_Exp	Ratio of government expenditure to GDP	Penn World Table
Openness	Ratio of country's total trade (export plus import) to GDP	Penn World Table
Edu_high	Population of working age with tertiary education degree	Eurostat
Edu_low	Population of working age with lower than secondary education degree	Eurostat
Unemploy	Unemployment rate	Eurostat

5.5 Results

Table 4 and Table 5 give the results of fixed effect panel regressions for ICT-related patenting activities against the measures of the size of the middle class. In Table 4 we present how the various time lag for the independent variable affect the correlation with the size of the middle class. It is shown that ICT-related patents do not have significant correlation with the size of the middle class when the time lag is less than 3 years. Thus, it suggests that time lag for patent does matter. It is in line with the previous research from Ken, Tsai, and Ou (2008) which proposes that there is a time lag of 4 to 5 years for patent to give impact to firm profitability in U.S pharmaceutical industry.

Table 4: ICT-related patent (innovation in digital economy) with various time lag and the size of the middle class

Variables		(1) mid_class	(2) mid_class	(3) mid_class	(4) mid_class	(5) mid_class
patent_ict_pop	lag 1 year	0.007				
		(0.011)				
patent_ict_pop	lag 2 years		-0.020			
			(0.014)			
patent_ict_pop	lag 3 years			-0.027**		
				(0.013)		
patent_ict_pop	lag 4 years				-0.024**	
					(0.012)	
patent_ict_pop	lag 5 years					-0.024**
						(0.012)
Gdpcap		-0.000**	-0.000**	-0.000**	-0.000**	-0.000**
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
pop_growth		0.058**	0.059**	0.058**	0.048*	0.047*
		(0.026)	(0.025)	(0.025)	(0.025)	(0.025)
edu_high		-0.034	-0.029	-0.043	-0.067	-0.051
		(0.065)	(0.066)	(0.064)	(0.063)	(0.063)
edu_low		-0.032	-0.021	-0.037	-0.052	-0.045
		(0.054)	(0.056)	(0.054)	(0.051)	(0.051)
gov_exp		-14.067**	-16.758**	-17.342***	-13.741**	-15.471**
		(6.595)	(6.553)	(6.528)	(6.421)	(6.421)
Openness		0.335	0.241	0.369	0.246	0.310
		(0.767)	(0.771)	(0.740)	(0.731)	(0.713)
unemploy		0.074	0.083*	0.072	0.042	0.050
		(0.046)	(0.046)	(0.045)	(0.045)	(0.045)
Constant		70.577***	71.576***	72.575***	72.937***	72.512***
		(3.030)	(3.005)	(2.978)	(2.922)	(2.950)
R-square		0.0917	0.0957	0.1047	0.0990	0.0969
Group (Countries)		31	31	31	31	31
N (Observation)		310	310	311	311	312

*** p < 0.01; ** p < 0.05; * p < 0.1.

Time span: 2003-2012 (12 years). Standard errors are in parentheses.

Meanwhile, using panel analysis of Germany manufacturing industry, Ernst (2001) find patent applications affect sales increases with a time-lag of 2 to 3 years after the priority year.

Since the strongest correlation is shown by 3 years of time lag, in Table 5 we present the results of the regressions between the 3-years-lag of independent variable and various measures of the size of the middle class. The results strongly indicate the relationship between innovations in digital sector and the size of the middle class. These relationships are significant and negative in all cases confirming our hypothesis that digitalization may lead to the shrinking of the middle class in European countries. As the robustness check, in column 4 we present the relationship between independent variable and income inequality indicators. The positive and significant correlation indicates that the shrinking size of middle class phenomenon is in line with the higher gap in the distribution of income.

Table 5: ICT-related patent (3 years lag) and the size of the middle class

Variables		(1) middle_class	(2) mid_60	(3) mid_40	(4) Gini
patent_ict_pop	lag 3 years	-0.027**	-0.017**	-0.011**	0.019**
		(0.013)	(0.007)	(0.005)	(0.009)
Gdpcap		-0.000**	-0.000	-0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
pop_growth		0.058**	0.050***	0.036***	-0.050**
		(0.025)	(0.014)	(0.010)	(0.021)
edu_high		-0.043	0.062*	0.034	-0.122**
		(0.064)	(0.036)	(0.026)	(0.049)
edu_low		-0.037	0.064**	0.041**	-0.069*
		(0.054)	(0.028)	(0.020)	(0.040)
gov_exp		-17.342***	0.501	0.895	0.719
		(6.528)	(3.694)	(2.654)	(4.738)
Openness		0.369	0.604	0.651**	-0.702
		(0.740)	(0.391)	(0.281)	(0.538)
Unemploy		0.072	0.070***	0.048***	0.016
		(0.045)	(0.025)	(0.018)	(0.034)
Constant		72.575***	49.585***	32.417***	33.630***
		(2.978)	(1.643)	(1.180)	(2.236)
R-squared		0.1047	0.0955	0.0979	0.0746
group (countries)		31	31	31	31
N (Observation)		311	329	329	358

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Time span: 2003-2012 (12 years). Standard errors are in parentheses.

- Column 1: Dependent variable is the share of population of the middle class between 60% and 150% median
- Column 2: Dependent variable is the share of income of middle class between 30%-80% population
- Column 3: Dependent variable is the share of income of middle class between 40%-70% population
- Column 4: Dependent variable is gini index as the measure of inequality (robustness check)

Table 6 demonstrates the results for ICT share in GDP and share of employment in ICT sector against the measures of the size of the middle class. Those two independent variables perform considerably worse than the ICT-related innovation variable. In the first and fifth column, it is shown that ICT share in GDP and employment in ICT sector have significant and negative correlation with the size of the middle class in 90 percent of confidence level interval. The results confirm the hypothesis that not only does innovation in digital sector affect the shrinking middle class, but the size of economies and employment in ICT sectors do also matter. The higher size of GDP proportion and the number of employment in ICT-sectors lead to the declining size of the middle class.

However, the results are not robust when we change the dependent variables from the population share (the first approach) to the income share (the second approach). The correlation between independent and dependent variables change into the positive direction as can be seen in the second, third, sixth and seventh columns. Thus, we conclude that the effect of ICT sector size in GDP and total employment on the size of the middle class is not clear in this model.

It means that the shrinking size of the middle class is not affected directly by the size of ICT sector. The explanation could be because the power of digitalization is not only benefited by those who work in ICT sector. Since ICT is a general purpose of technology, its impact will occur across sectors. The role of ICT is different from prior technological revolutions which generally disrupt only a specific sector at a time but then are able to generate new emerging industries (Ford, 2015). In contrast, innovations in ICT broadly affect numerous occupations in all sectors of industry. Therefore, approaching digitalization indicator by the contribution of ICT sector to the GDP and total employment could be misleading.

Table 6: ICT size in GDP, ICT employment and the size of the middle class

Variables	(1) middle_class	(2) mid_60	(3) mid_40	(4) Gini	(5) middle_class	(6) mid_60	(7) mid_40	(8) gini
ICT_GDP	-0.000*	0.000*	0.000**	0.000				
	(0.000)	(0.000)	(0.000)	(0.000)				
ICT_employee					-1.141*	0.435*	0.328*	-0.083
					(0.688)	(0.231)	(0.167)	(0.442)
Gdpcap					-0.000	0.000	0.000	0.000
					(0.000)	(0.000)	(0.000)	(0.000)
pop_growth	0.162***	0.062**	0.048***	-0.122***	0.123***	0.078***	0.058***	-0.115***
	(0.045)	(0.024)	(0.017)	(0.033)	(0.041)	(0.021)	(0.015)	(0.029)
edu_high	-0.424***	-0.062	-0.047	0.117	-0.139	-0.021	-0.020	-0.039
	(0.107)	(0.059)	(0.043)	(0.075)	(0.101)	(0.052)	(0.038)	(0.066)
edu_low	-0.136	0.023	0.017	0.029	-0.047	0.038	0.022	-0.063
	(0.085)	(0.040)	(0.029)	(0.057)	(0.087)	(0.040)	(0.029)	(0.055)
gov_exp	-20.143**	7.490	5.374	-1.386	-28.193***	6.704	4.649	0.401
	(8.755)	(4.907)	(3.547)	(5.999)	(9.999)	(4.644)	(3.350)	(5.976)
Openness	1.787	1.080*	0.767*	-1.370*	1.324	1.076**	0.779**	-1.239*
	(1.106)	(0.563)	(0.407)	(0.802)	(1.082)	(0.531)	(0.383)	(0.739)
Unemploy	0.251***	0.103***	0.075***	-0.089**	0.232***	0.093***	0.066***	-0.066
	(0.056)	(0.030)	(0.022)	(0.040)	(0.062)	(0.031)	(0.022)	(0.042)
Constant	79.553***	50.198***	32.791***	28.684***	76.364***	48.604***	31.988***	34.030***
	(4.808)	(2.482)	(1.794)	(3.159)	(4.797)	(2.220)	(1.602)	(2.973)
R-squared	0.2192	0.1025	0.1081	0.0889	0.1595	0.1256	0.1266	0.1065
group (countries)	26	26	26	26	27	27	27	27
N (Observation)	195	216	216	220	214	234	234	242

*** p < 0.01; ** p < 0.05; * p < 0.1. Time span: 2003-2012 (12 years). Standard errors are in parentheses.

6. Conclusion

Many previous studies attempt to elaborate the effect of digitalization on the distribution of income. Nevertheless, little is known about its impact on the shrinking size of the middle class in particular. Meanwhile, essentially, the rise of income inequality and the shrinking middle class are two sides of the same coin. The proponent of skill biased technical change (see for instance Acemoglu, 2002; Autor, Levy, and Murnane, 2003) argues that income inequality rises because middle-class workers are replaced by computerization and automation. As a consequence, the size of those in the middle decline along with the increase polarization between high skilled and low skilled workers.

Randal Collins (2013) is the first who explicitly link the digitalization and computerization and the shrinking of the middle class in sociological perspective. In this study, we construct a hypothesis by linking Collins (2013) proposal to the evolutionary economics discourse and the term of creative destruction introduced by Joseph Schumpeter. Then, this study is the first which test the relationship empirically with EU countries as the unit of the analysis in the period 2003-2012. The results are summarized in Table 7.

Table 7: Summary of results

	Measure of Middle Class			Measure of Inequality
Variable	Share of Middle class size (60%-150% median)	Share of Middle 60 income (30%-80% of earners)	Share of Middle 40 income (40%-70% of earners)	Gini index
Measure of Digitalization				
Patent in ICT Sector (Innovations)	Negative **	Negative **	Negative **	Positive **
ICT in GDP (economics)	Negative *	Positive *	Positive *	Not Significant
ICT employment	Negative *	Positive *	Positive *	Not Significant

We find the evidence of a negative link between digitalization and the size of the middle class, but the result is highly sensitive to the definition of middle class as the dependent variable. As suggested by Piketty (2014), the term of middle class is debatable because it does not have any single definition. The most consistent effect is shown when we define the middle class as the share of households whose incomes are between 60 percent and 150 percent median.

While there appears to be only limited effect of ICT contribution on GDP and total employment on the size of the middle class, the evidence is highly significant in the effect of innovation in digital sector as measured by ICT-related patents on the size of the middle class. One explanation for this might be ICT-related innovation is benefited not only by those in ICT sectors, but also the wide array of occupations. Therefore, approaching digitalization indicator by the contribution of ICT sector to the GDP and total employment could be misleading. With this paper, we have provided only the first test of the relationship between digitalization and the size of the middle class.

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