Changes in Unrelated Variety and Climbing Poverty Ladder: A U-shaped Relationship

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Caption list:

Figure 1: Concept of unrelated variety
Figure 2: The theoretical framework of the U-shape relationship
Figure 3: Understanding the relationship between ΔUV and ΔEXP with the law of DMPC
Figure 4: the U-shape relationship in our Yugoslavia case

Changes in Unrelated Variety and Climbing the Poverty Ladder: A U-shaped Relationship

Abstract: The purpose of this paper is to study how changes in unrelated variety influence individuals' poverty alleviation. Drawing on the LiTS III database, we employed the Oprobit model to test 5007 individual-level observations from 23 regions in four former Yugoslavian countries. All results imply that the changes in unrelated variety have a U-shaped relationship with individuals' poverty alleviation. Our findings enrich the unrelated variety research by providing micro-level evidence and offer practical insights for governments, organizations, and individuals aiming to reduce poverty.
Keywords: unrelated variety, poverty alleviation (climbing poverty ladder), U-shape, Former Yugoslavia, Oprobit model
JEL codes: P36, R11

1. Introduction

Unrelated industrial variety (hereafter, unrelated variety) is a critical concept in economic geography (Content & Frenken, 2016). Coined by Frenken et al. (2007), unrelated variety describes the regional industrial structure, in which regional two-digit sectors do not share a common knowledge base, with cognitive distance among sectors. After Frenken et al., studies on unrelated variety, as well as its "twins" concept related variety, have achieved fruitful research achievements. The most important contribution of Frenken et al.'s paper is that it deepened our knowledge of Jacobs' diversification argument in economic geography (Ejdemo & Örtqvist, 2020).

Economic geography is a scientific discipline that aims to uncover the "human-economy-geography" relationship (Milbourne, 2010): geographic features influence people's behaviors and performances (e.g., Bertazzini, 2022), and people's behaviors and future expectations reshape current geographic features (e.g., McGirr et al., 2015). If we acknowledge the important role that human beings play in geography, it is easy to find that contemporary unrelated variety studies face a major challenge: most of them set their research focus either at the regional level – such as regional employment growth (e.g., Firgo & Mayerhofer, 2018), regional entrepreneurship (e.g., Content et al., 2019), or regional innovation (e.g., Ejdemo & Örtqvist, 2020) – or use variables at the

firm level, such as firm sales (e.g., Lu et al., 2022). However, individuals' behavior and performance have not attracted much attention from geographers, which implies that unrelated variety studies do not have a solid micro-foundation. Even though unrelated variety may influence regional development, how such influence occurs at the individual level and how individuals respond to such influence remains unknown. As Content and Frenken (2016, p.2019) summarized in their literature review paper, **a theoretical gap becomes obvious**: "*studies hitherto focus on how (un)related variety affects economic development, while research ... at the micro-level remains rather unconnected to the (un)related-variety literature.*"

Studying **individual poverty alleviation (hereafter, poverty alleviation)** is an ideal starting point for filling in the above research gap. Although government, community, and non-profit organizations can do things to reduce poverty, such as handing out vouchers (e.g., Burchardi et al., 2021), poverty alleviation per se is mainly related to individuals' attitudes, choices, and behaviors (e.g., Ham & Michelson, 2018). Poverty alleviation constitutes an invisible foundation for individuals' daily life: the only thing that a person who suffers from poverty can do is to fight for his or her "next meal." Thus, connecting unrelated variety with poverty alleviation makes sense. On one hand, poverty is a geographic phenomenon (Milbourne, 2010, p.162). On the other hand, regional industrial structure can impact individuals' wealth through occupations, average salary, and job prospects (e.g., Cloutier, 1997).

The present paper aims to fill in the above-mentioned research gap. We build a theoretical framework, explaining that the changes of unrelated variety and individual poverty alleviation appear to be U-shaped. We test our framework empirically by 5007 individual-level observations of four former Yugoslavian countries. We apply the Oprobit model to test our framework and we also conduct robustness tests. All results support our framework.

This paper makes the following contributions. Firstly, we enhance micro-foundation of unrelated variety research by providing individual-level evidence. Without taking individual's behavior and performance into account, the concrete mechanism on how unrelated variety impacts regional development is a "black box."

Our paper is positioned at the individual level, which most prior studies have ignored (Content & Frenken, 2016). Secondly, unlike many prior studies that explore unrelated variety with a static viewpoint (e.g., Content et al., 2019; Tomasz & Pawel, 2021), our paper provides a dynamic viewpoint by tracing changes of unrelated variety. Thirdly, our paper extends knowledge on poverty alleviation by showing that unrelated variety matters. Although Frenken et al. (2007) proved that unrelated variety dampens regional unemployment, or at least makes regional unemployment stable (e.g., da Silva et al., 2020), low regional unemployment does not necessarily make every local person less poor. For example, people who live in a region that has many different sectors, but all of those sectors provide low-paid jobs, may find that they only experience fatiguing work (Ambler et al., 2021). The present paper contributes to the understanding that small changes of unrelated variety are a burden of poverty alleviation, but major changes of unrelated variety benefit poverty alleviation.

The remainder of the paper is organized as follows. Section 2 introduces the theoretical framework and advances the hypothesis. Section 3 presents our research methodology, including data collection, variables, and regression models. Section 4 presents the regression results and conducts robustness tests. The final section concludes our analysis and discusses the study's implications.

2. Theoretical Background and Hypotheses

This section contains three parts. The first subsection elaborates the concept of unrelated variety. The second subsection introduces knowledge about poverty reduction in a geographic perspective. The final subsection generates the research hypothesis.

2.1 The concept of unrelated variety

Unrelated variety is a concept raised by Frenken et al.'s (2007) classic paper, in which the authors advance their (un)related variety perspective. In theory, **"unrelated variety refers to industrial sectors in a region that have a high cognitive distance"** (Erkus-Ozturk, 2016, p.423). In Aarstad et al.'s (2016, p.845) viewpoint, unrelated

variety can be understood as regional firms in different industrial sectors (hereafter, sectors for short) that share few similarities. Considering the information given by the definition of unrelated variety is abstract, we provide more theoretical background below.

Unrelated variety originated from Frenken et al.'s reconsideration of Jacobs' externality argument. Frenken et al. (2007) extended Jacobs' argument by dividing diversification into two types: related variety and unrelated variety. We highlight two points here. The first is about the relationship between Jacobs and Frenken et al. Frenken et al. unconsciously inherit Jacobs' two different arguments. Frenken et al.'s related variety concept was inspired by Jacobs' argument on urban economics. Frenken et al. employed unrelated variety to reflect Jacobs' (1961) argument on urban planning, which is how unrelated sectors commonly contribute to city life. The second point is that the criterion of judging whether two sectors are related or unrelated is unique, and such criterion is the knowledge base (Firgo & Mayerhofer, 2018; Hesse & Fornahl, 2020). Taking unrelated variety as an example, two sectors are unrelated because they do not have a common knowledge base. Thus, it is difficult to spread knowledge from one sector to another (Cainelli et al., 2019; Herstad, 2018).

Although Frenken et al.'s unrelated variety concept is closely related to the knowledge-based view, Frenken et al. (2007) simplified their theory when conducting empirical tests. Frenken et al. employed the industrial classification system (regardless of whether it is the NACE, NAICS, or SIC system) to identify knowledge similarity. Frenken et al. simply assumed that two-digit sectors would not share a similar knowledge base. Therefore, the essence of unrelated variety consists of three aspects. Firstly, unrelated variety has geographic attributes. The concept of unrelated variety not only reflects industrial sector relatedness, but also how industrial sectors are related within certain geographic boundary. Such a geographic boundary normally fits an administrative boundary. For instance, it could be NUTS-1, NUTS-2, or NUTS-3 regions in Europe (e.g., Content et al., 2019), or it could be state-level and city-level in the United States (e.g., Castaldi et al., 2015). Secondly, unrelated variety is related to the number of two-digit sectors, but is unrelated to the size and number of three- or

four-digit industries under the same two-digit sector. Thirdly, unrelated variety is also highly related to the distribution of size of each two-digit sectors. More specifically, when local people are evenly distributed across all two-digit local sectors, then unrelated variety is high. When a few two-digit local sectors provide most jobs for local people, unrelated variety is low. In sum, unrelated variety describes a regional industrial structure phenomenon: when a region contains a lot of unrelated sectors and every sector's size develops equally, the region's unrelated variety is high; and vice versa.

Figure 1 visualizes what unrelated variety is.

<Insert Figure 1 about here>

2.2 Relevant knowledge on poverty

Poverty refers to an economic phenomenon that exists when an individual's or a household's income falls short of socially acceptable living standards (Lipton & Ravallion, 1995, p.2553). Poverty can be also defined as a segment of the population that lacks opportunity or the ability to gain social recognition, general diet, and living conditions, emphasizing that poverty is not only low income, but a deprivation of basic capacity (Bank, 2000).

Poverty has a clear geographical attribute: it is spatially clustered (Curtis et al., 2019). A region with high rates of poverty will always neighbor other regions that are also poor (Glasmeier, 2014). Furthermore, spatial poverty is a persistent phenomenon brought about by low geographical capital, including adverse location characteristics and excessive migration costs (Zhou & Liu, 2022). The concentricity and persistence of poverty in geography generally lead to geographic isolation, limited access to public infrastructure and service, restricted institutional support, and higher risk and greater exposure to environmental toxins (Dong et al., 2021). The spatial clusters of poverty could be relieved when economic conditions and economic inequality are broadly improved (Albrecht & Albrecht, 2000; Lichter & Johnson, 2007; Weber et al., 2005). For example, when industrial shifts and transitions occur appropriately with tax and welfare policy, spatial inequality declines, and regional poverty is thereby reduced (Lichter et al., 2014).

The social outcomes and consequences of regional industrial structure in poverty alleviation have sparked interest in different disciplines in recent decades (Palomino et al., 2020). Specifically, based on the endowment of impoverished area, the influence of industrial structure shifts and transitions has made progress on poverty alleviation with the guidance from market demand, preferential policy support, proactive effect form poor people, and jointly implements with governments, financial institutions, technical advisory groups, and cooperative organizations (e.g., Liu et al., 2021). There are other ways to increase a household's income and improve the living conditions of the poor by helping poor farmers to achieve self-development of agricultural industry, including providing technical and information services in agricultural skills of production, sale, storage, processing, and transportation. Therefore, regional industrial structure has been increasingly regarded as one of important factors that can impact poverty alleviation.

Being at the top of the United Nations' Sustainable Development Goals, reducing poverty is not easy. **Poverty alleviation refers to a process that improves the shortage of social existence, adaptability, and development ability, specifically access to education, job creation, better health and housing, and reducing inequality** (Bank, 2017). Korosteleva and Stępień-Baig (2020) used the term "**climb the poverty ladder**" to describe the poverty alleviation process, explaining that the ladder is large enough to accommodate all people, but that everyone's position on the ladder depends on his or her poverty status. The poverty alleviation process is like a person climbing up the ladder from bottom to top. In the present paper, **we use the terms "poverty alleviation" and "climbing the poverty ladder" interchangeably**.

2.3 Hypothesis development

In this sub-section, we develop a hypothesis that shows why the relationship between "changes of unrelated variety and poverty alleviation" is U-shaped. We follow Haans et al.'s (2016) template from their paper published in the *Strategic Management Journal*, in which the authors noted that any (inverted) U-shape is formed by two forces. Accordingly, we deconstruct an individual's poverty alleviation into two forces: changes of earnings and changes of expenditure. Figure 2 visualizes our logic.

The first force is changes of earnings (ΔE). Inspired by John Keynes (1936), we deconstruct an individual's earnings into three parts: wages, interests, and entrepreneurship (Parkin, 2016). Before we explore the relationship between **changes in unrelated variety (ΔUV)** and ΔE, we must emphasize that in order to facilitate explanation, when we mention changes in unrelated variety from here on in, such changes are positive, which implies that new and unrelated sectors emerge and every sector develops well and equally.

Regarding wages, big changes in unrelated variety mean that new emerging sectors will create a lot of jobs for local individuals, who will have choices and alternatives to work in sectors where they can maximize their productive. Referring to Solow's (1979) efficiency wages argument, noting that "wages are an **increasing function** of labor productivity" (Tomasz & Pawel, 2021, p.226), it is easy to infer that growth of productivity due to job optimization would lead to wages appearing in an increasing return.

Regarding interests, we consider both banking interests and non-banking interests (Creedy & Gemmell, 2017). For a normal individual, the amount that he or she can save depends on his or her wages. The higher wages an individual has, the greater the possibility that he or she could receive interest from a bank for deposits. As we have mentioned that wages increase marginally due to ΔUV increases, deposits, which depend on wages, from bank interest then should increase marginally. In terms of non-banking interests, when there are a lot of emerging sectors, people have demand for capital from non-bank channels to create and seize new business opportunities (Bavoso, 2019). Consider person-to-person (P2P) loans as an example. On one hand, although it is risky, P2P helps alleviate entrepreneurs financial pressure (Jin et al., 2021). On the other hand, interest rates of P2P are much higher than those of commercial banks because of the high risk of default (Deng, 2022). Therefore, people's changes in earnings from interests also have a marginal return.

Regarding entrepreneurship, it is extra earnings that pay for entrepreneurs' talents (Parkin, 2016). We highlight two points: similar to wages, as entrepreneurs' productivity increases, their "wages" for their talents also increase marginally. More

importantly, compared to small changes in unrelated variety, entrepreneurs can find more business opportunities when changes in unrelated variety are great. Accordingly, entrepreneurs' earnings would grow in a marginally increasing return.

As shown in Figure 2 (P1), we make the following proposition:

Proposition 1: ΔUV and individual's ΔE appears in a marginally increasing relationship.

<Insert Figure 2 about here>

The second force is changes of expenditure (ΔExp). Unrelated variety constitutes the base of probability for individuals' expenditure: the more unrelated industries, the more consumption alternatives and opportunities. This is easy to understand, simply imagine that for instance living in New York, whose unrelated variety is high, has more consumption choices than living in a rural region, whose unrelated variety is low. Furthermore, it is well known that consumption follows Keynes' "the law of diminishing marginal propensity to consume" (hereafter, the law of DMPC), which consists of two key points: (1) when people's income increases, consumption also increases, but the proportion of consumption increase is not as large as that of income increase; (2) when income decreases, consumption also decreases, but not as much as income (Treynor, 2013). In line with the law of DMPC, although increasing unrelated variety can enrich consumption choices for local people, the consumption per se would be marginal decreasing. Accordingly, the relationship between unrelated variety and expenditure is shown by Figure 3.

<Insert Figure 3 about here>

We must note that tracing "UV and expenditure" relationship is not our focus, finding how ΔUV influences ΔExp is our focus. We then draw ΔUV and ΔExp in Figure 2 respectively. For instance, we can easily find the cohort (ΔUV_1 and ΔExp_1) and the cohort (ΔUV_2 and ΔExp_2), and etc. It is easily to make two conclusions: (1) as ΔUV increases, ΔExp increases as well. (2) growth ratio of ΔExp is marginal decreasing. For instance, the gap between ΔExp3 and ΔExp2 is less than the gap between ΔExp2 and ΔExp1. That is to say: as ΔUV increases, ΔExp would be marginal decreasing.

In her classic book *The Death and Life of Great American Cities*, Jacobs (1961)

provided a viewpoint on city planning. She argued that public facilities will become more efficient and economical when cities are constituted by unrelated sectors. Jacobs (1961, chapter 7) provided an example of Manhattan, in which she noted that such an area lacks (unrelated) variety; therefore, the living costs are high and people experience inconvenience. In Jacobs' view, in a city with various unrelated sectors, people's living expenditures would increase at a diminishing rate. In the present paper, we follow Jacobs' logic to provide a concrete example. Regarding public transportation, when changes in unrelated variety are large, this implies that more and more people need to take public transportation at different times and places. Therefore, on one hand, local individuals' ΔExp on public transportation will increase because bus or subway firms will open more routes to fit consumers' potential demands; on the other hand, the more consumers take public transportation, the less cost each individual will bear.

Building on above illustration, as shown in Figure 2 (P2), we advance the following proposition.

Proposition 2: ΔUV and individual's ΔExp appears in a marginal decreasing relationship.

Because poverty alleviation depends on the gap between ΔE and ΔExp, as shown in Figure 3 (H), we raise the following research hypothesis:

Hypothesis: ΔUV and poverty alleviation appear in a U-shaped relationship.

3. Methodology

3.1 Research context and data sources

We chose four former Yugoslavian countries – Croatia, North Macedonia, Serbia, and Slovenia – as our research objectives, for two reasons. Firstly, our research objective is poverty. Countries in southeast Europe are relatively poor compared to other European countries. According to the Eurostat statistics, for instance, in 2019, total GDP of the four above-mentioned countries was approximately 161.2 billion euro, which made up less than 0.89 percent of Europe's total GDP. Secondly, former Yugoslavian countries have common historical and cultural background, but after the

break-up of Yugoslavia, the four countries began to develop independently, which helps to diversify our observations.

We gathered data from four sources. The first was the Orbis Database (https://orbisip.bvdinfo.com/), which we employed to calculate unrelated variety. The second source was The European Bank for Reconstruction and Development (EBRD, https://www.ebrd.com/home), where we employed the most recent wave of EBRD life in Transition Survey (LiTS) III in 2016. The LiTS III was one of the surveys conducted by the EBRD and the World Bank, which provided details about the respondents' and their families' circumstances, life satisfaction, and values. The other two sources were the Eurostat (https://ec.europa.eu/eurostat/) and European Urban Data Platform Plus (https://urban.jrc.ec.europa.eu/), from which we downloaded regional economic data. We eventually obtained 5007 observations from 23 regions in four countries. Note that while the former Yugoslavia consists of six present-day countries, we excluded Bosnia and Herzegovina and Montenegro mainly because of their poor-quality data. Last but not least, all data we employed are open, transparent, and traceable.

3.2 Variables

3.2.1 Dependent variable

We set changes of poverty ladder (ΔPL) as our dependent variable. Respondents in LiTS III were asked to imagine a 10-step ladder where, at the bottom, the first step, stands the poorest 10 percent people in their countries, and on the highest step, the tenth, stands the richest 10 percent people in their countries. The respondents were asked to assess on which step they felt their household stood in 2016. The higher the value, the richer the respondents' household. To better investigate the respondents' poverty changes, they were also asked to access their poverty ladder four years ago (in 2012). **We calculated the changes on the poverty ladder during the four years; mathematically, ΔPL means a person's score in 2016 minus his or her score in 2012**. If **ΔPL** was positive, it meant the respondent became richer; if the value was zero, it meant their poverty status did not change; otherwise, they became poorer (Korosteleva & Stępień-Baig, 2020).

3.2.2 Independent variable

Drawing on European Industry-standard classification (NACE), the unrelated variety of each region is indicated by the entropy of the two-digit distribution. Each four-digit sector is exclusively under a two-digit sectors S_g where g=1,2,…G. We then derived the two-digit shares by summing the four-digit shares p_i.

$$P_g = \sum_{i \in s_g} P_i$$

Unrelated variety (UV), or the entropy at the two-digit level in a certain year, is given by:

$$UV = \sum_{g=1}^{G} P_g \ln(\frac{1}{P_g})$$

We calculated UV for all 23 regions, both in 2016 and in 2012. We then calculated UV changes during the period between 2012 and 2016. We generated delta UV (in math, ΔUV), which is every UV in 2016 minus UV in 2012.

Because we paid attention to the nonlinear relationship, **the quadratic terms of delta UV are the independent variable in our paper**. In math, it is:

$$\Delta UV^2 = (UV2016 - UV2012)^2$$

3.2.3 Control variable

We add control variables at both the individual level and regional level. At the individual level, we controlled for correspondents' age (Asri, 2019), gender (Reboul et al., 2021), marital status (Demissie, 2017), location (Turok & Borel-Saladin, 2018), education attainment (Cao et al., 2016) and home internet access status (Glaeser et al., 2017). At the regional level, we also controlled for GDP in those regions (Devarajan, 2018).

Table 1 provides variable details. For instance, the average of ΔUV^2 is 0.003. People's poverty status ranges from -7 to 9 in our sample, but nearly 98.0 percent of the respondents' poverty change from -3 to 2.

<Insert Table 1 about here>

Table 2 reports the correlation matrix of all variables used in estimates.

<Insert Table 2 about here>

3.3 Regression model

As mentioned before, respondents in LiTS III were asked to provide an assessment of their current level of poverty using a 10-level poverty ladder ranging from 1 to 10, which generated a set of data in the form of ordered responses. Moreover, because we calculated the delta poverty ladder to reflect the poverty changes from 2012 to 2016, the data is also a sequence of **Ordered** numbers that should range from -9 to 9 (in our paper, the true value is from -7 to 9, and there are 17 different values in total). If we had only employed the ordinary least square estimates, the results could have been biased and inconsistent. Accordingly, we mainly employed the ordered probit model (hereafter, Oprobit model), which is suitable for estimating the relationship between ordered dependent variables and continuous independent variables (Daykin & Moffatt, 2002). The multivariate linear equations can be written as followed:

$$\Delta PL_{ij}^{*} = \beta_0 + \beta_1 \Delta UV^2{}_j + \beta_2 \Delta UV_j + \beta_3 lnAge_{ij} + \beta_4 Gender_{ij} + \beta_5 Married_{ij} + \beta_6 Urban_{ij} + \beta_7 Education_{ij} + \beta_8 Internet_{ij} + \beta_9 lnGDP_j + \varepsilon_{ij}$$

Where i refers to respondent i, and j refers to region j; ΔPL_{ij}^{*} refers to the latent variable of the delta poverty ladder of respondent i in region j. $lnAge_{ij}$, $Gender_{ij}$, $Married_{ij}$, $Urban_{ij}$, $Education_{ij}$, $Internet_{ij}$ refer to age, gender, marital status, location, education attainment and home internet access status, respectively; $lnGDP_j$ refers to GDP; β are the coefficients; ε_{ij} is the error term.

The relationship between the unobservable latent variable ΔPL_{ij}^{*} and the observable ordered variable ΔPL_{ij} can be written as followed:

$$\Delta PL_{ij} = F(\Delta PL_{ij}^{*}) = \begin{cases} 0, & \Delta PL_{ij}^{*} \le r_0 \\ 1, & r_0 < \Delta PL_{ij}^{*} \le r_1 \\ & \cdots\cdots \\ 16, & r_{15} < \Delta PL_{ij}^{*} \le r_{16} \\ 17, & r_{16} < \Delta PL_{ij}^{*} \le r_{17} \end{cases}$$

Where ΔPL_{ij} refers to the delta poverty ladder, and the solve-for parameter (also

known as cutoff points or "cut" in Stata) satisfies $r_0<r_1<r_2\ldots<r_{17}$, which divided ΔPL_{ij}^* into 17 intervals. The Oprobit model can be written as followed:

$$\Delta PL_{ij} = F\left(\Delta PL_{ij}^*\right)$$

$$= F(\beta_0 + \beta_1 \Delta UV^2{}_j + \beta_2 \Delta UV_j + \beta_3 lnAge_{ij} + \beta_4 Gender_{ij}$$

$$+ \beta_5 Married_{ij} + \beta_6 Urban_{ij} + \beta_7 Education_{ij} + \beta_8 Internet_{ij}$$

$$+ \beta_9 lnGDP_j + \varepsilon_{ij})$$

Using the maximum likelihood estimation, we can conclude all the coefficients of the Oprobit model.

4. Regression Results and Robustness Tests

4.1 Regression results

The basic regression results were shown in Table 3. We firstly estimated the U-shape relationship between ΔPL and ΔUV^2 using the OLS model, and the results with regression are shown in column (1) of Table 3. Columns (3) in Table 3 report the results of Oprobit model. As we can see in Table 3, all the coefficients of ΔUV^2 are positive and significant, showing the U-shaped effect of ΔUV^2 on the ΔPL.

<Insert Table 3 about here>

Furthermore, we added controls at both the individual level and the regional level in Columns (2) and (4), and the results are robust. The relationship between marriage and ΔPL is positive and significant, indicating that marriage could help alleviate poverty. One possible explanation is that marriage establishes a productive household arrangement in which men and women divided their tasks and the whole family obtains higher anti-risk ability. Age is negatively related to ΔPL. It is probably the case that young individuals are usually more energetic and creative, and better educated than older ones, so young people can make more money to alleviate poverty.

The marginal effects of ΔUV^2 based on the results in Column (4) of Table 3 are reported in Column (1) of Table 4. As we can see, for the individuals who become poorer, the coefficients are negative and significant; while for the individuals whose poverty status remains stable or improves, the coefficients are positive and significant.

This finding indicates that, with the change of unrelated variety rising, people's poverty status tends to go up instead of down. In particular, the marginal effects are insignificant when the poverty ladder changes too much ($\Delta PL<-5$ or $\Delta PL>4$ in our study). Our full sample does contain outliers, but they do not affect our results, which will be proven in our robustness checks below.

In sum, **the results show support for that our hypothesis that** changes in unrelated variety and poverty ladder climb appear in a U-shape.

<Insert Table 4 about here>

4.2 Robustness tests

4.2.1 Ologit, Meoprobit, and Meologit methods

We conducted a further check by employing the Ordered Logit model (Ologit); the results are reported in Column (1) of Table 5. Specifically, the main difference between Oprobit model and Ologit model is the hypothesis of residual; that when the sample size is large enough, the two models usually have plausible similar results.

Considering the hierarchical structures between respondents and regions, in Columns (2) and (3) of Table 5 we employed the Meoprobit (Multilevel-effects ordered probit regression) model and Meologit (Multilevel-effects ordered logistic regression) models, respectively. Both meoprobit and meologit models are random intercept models.

The relationship between ΔUV^2 and ΔPL are consistently positive and significant. The marginal effects of the above three models are reported in Columns (2), (3) and (4) of Table 4, and the results keep in line with Oprobit model.

<Insert Table 5 about here>

4.2.2 Excluding extremely poor or rich individuals from full sample

As mentioned in our descriptive statistics of Table 1, individuals' assessments about their poverty ladder vary widely, and most people's poverty status are at a medium level. For example, more than 89.1 percent of respondents' poverty ladders range from Level 3 to Level 8, 9.75 percent are below Level-3, and only 1.1 percent are

on the top rung of the ladder, indicating the richest people in their countries. In this part, we divided the individuals into three parts according to their position on the poverty ladder: the bottom 20 percent, the middle 60 percent and the top 20 percent. We tested the U-shaped relationship between ΔUV^2 and ΔPL for these three groups, respectively, and Columns (4), (5), and (6) of Table 5 reported the results. We found that apart from the bottom 20 percent of samples, the coefficients of ΔUV^2 are positive and statistically significant among the other two groups, which implies the U-shape relationship still exists. Especially, for individuals whose poverty ladders are over Level 8, the U-shape gets sharper.

4.2.3 Excluding outliers

We found that some individuals' poverty status changed quite a lot, meaning that some people became extremely poor or rich during the period. This is not common in real life. We decided to exclude individuals whose poverty ladder changed greatly (delta poverty ladder below -3 or over 3) from the full sample and conduct the Oprobit model again. Column (7) of Table 5 reports the estimate result and shows that the U-shaped relationship between poverty alleviation and change of unrelated variety still exists.

4.2.4 The cube of unrelated variety

To test the relationship between ΔUV^2 and ΔPL is U-shape instead of S-shape, we generated the cube of unrelated variety (ΔUV^3) and added it into Oprobit model with ΔUV^2 and ΔUV. The regression result is reported in Column (8) of Table 5. We can see that the coefficient of ΔUV^3 is not significant, while the coefficient of ΔUV^2 is still positive and significant, which implies that the S-shape does not exist and provides further powerful support for our hypothesis.

4.2.5 An exclusive test: related variety

This paper focuses on unrelated variety, but we must take the other type of industrial relatedness – related variety – into consideration because changes of related variety may also lead to poverty alleviation. The related variety of each region is given

by:

$$RV = \sum_{g=1}^{G} P_g H_g$$

where:

$$H_g = \sum_{i \in S_g} \frac{p_i}{p_g} \ln\left(\frac{1}{p_i / p_g}\right)$$

Where p_i refers to the four-digit share of employees. We generate delta RV (in math, ΔRV) which is every RV in 2016 minus RV in 2012, as well as the quadratic terms of delta RV as independent variables. Mathematically, it is:

$$\Delta \mathrm{RV}^2 = (\mathrm{RV2016} - \mathrm{RV2012})^2$$

To test whether the change of related variety does help to alleviate poverty and make a comparison with unrelated variety, we again apply the Oprobit model and the results are shown in Column (9) of Table 5. The relationship between ΔRV^2 and ΔPL is insignificant. Therefore, in our case, changes in related variety (neither ΔRV nor ΔRV^2) do not have impact on poverty alleviation.

4.2.6 Adding or changing control variables and mean-centering variables

Selecting control variables is not only a statistic issue, but also reflects different research philosophy[1]. Therefore, we need to do more robustness checks.

Although we have taken outliners into consideration in subsection 4.2.3, we cannot deny a fact that is we cannot observe those people whose poverty level was at a minimum level in 2012 as well as those people whose poverty level was at maximum level. Except simply treated the richest and poorest people as outliers, an alternative is that we add individual's poverty ladder in 2012 as control variable. The logic is that an individual's original poverty level could and should have big influence on his or her poverty ladder climbing[2]. The regression results are given in column (1) of Table 6, and ΔUV^2 is positively related to poverty alleviation.

[1] We appreciate our anonymous reviewer for mentioning this thing.

[2] In order to have to same logic as other regressions in this subsection, we mean-centering the poverty ladder in 2012.

Furthermore, except ΔUV^2, there might other variables at regional level can have second-degree polynomial relationship with poverty alleviation. We then take both $lnGDP^2$ and RPD^2 (regional population density) as controls. The results are given in column (2) of Table 6, and all conclusions do not change. In order to make the independent variable to be more normalized distribution, we mean-center the independent variable both for ΔUV^2 and ΔUV. Column (3) of Table 6 shows the results, and it does not change our main conclusion. Last but not least, considering that changes in regional GDP may also influence poverty alleviation, we control ΔGDP and ΔGDP^2, we find that the U-shape still exists (see column (4) of Table 6).

<Insert Table 6 about here>

4.2.7 U-shaped test

In order to further prove the U-shaped relationship exists, we calculated the slopes on both the left and right side and extreme point of the U-shape (Lind & Mehlum, 2010); the results are reported in Table 7. The interval of ΔUV is (-0.282, 0.111) and the extreme point is -0.037, indicating that the tripping point is in the monotone interval. The slope is -5.243 in the left interval and 3.141 in the right interval, and both values are statistically significant, which reconfirms the U-shape relationship between UV and poverty ladder. We visualize the U-shape in Figure 4 to clarify the relationship.

<Insert Table 7 and Figure 4 about here>

5. Conclusions

This paper aims to analyze how the change of unrelated variety influences poverty alleviation. Drawing on the LiTS III database and firm data about four relatively poor Former Yugoslavia countries, our results show that a U-shaped relationship exists between ΔUV^2 and ΔPL. We constructed two forces, named changes of earnings and changes of expenditure, to elaborate on the U-shaped relationship. To affirm the U-shape relationship is robust and consistent, we also provided several robustness checks.

Our research has made the following contributions. While most prior studies have

focused on the regional level or the firm level (e.g., Firgo & Mayerhofer, 2018), we focused on the individual level to explore how unrelated variety affects individuals climbing the poverty ladder. In addition, our study not only considers the ΔUV's effect on poverty ladder, but also provides a special viewpoint to explore their nonlinear relationship, which is realistic and closely related to the reality. Unlike prior scholars, who merely explored the industrial characteristics such as diversity, specialization as well as variety and poverty alleviation separately, or focused on the whole region's development, our study builds a bridge between regional industrial structures and individuals' poverty reduction. The results provide contributions for both scholars and policy makers, and even for individuals aiming to improve living standards.

This paper has two practical implications. To poor people, they can change their position in "poverty ladder" by moving from one region to another region. Regional industrial structure, particularly change in unrelated variety matters. Generally, poor people should go to the region, where its ΔUV is positive and keeps growing. To policy makers in poor region, they have to realize that reducing individual poverty alleviation through changing regional industry structure is not easy. In the beginning, local people poverty situation may become worse and worse, and local people then may be against the policy. However, when ΔUV goes cross the turning point, local individual's poverty would be reduced gradually.

Our study has certain limitations. An obvious limitation of our paper is that we only studied four countries of the former Yugoslavia, and we are not sure that whether our results fit realities in other countries in mainland Europe or fit realities in rich countries such as the Nordic countries.

According to the United Nations, before the COVID-19 pandemic approximately 8 percent of the world population lived in extreme poverty and could not fulfill their most basic needs (the United Nations[3], 2022). Now the globe is facing more challenges and uncertainties to eliminate poverty. Our study provides a few remarks to help reduce poverty from an industrial structure perspective. We hope that economists, business

[3] The information is seen in the United Nations homepage: https://www.un.org/sustainabledevelopment/poverty/. Accessed in May, 2022.

scholars and economic geographers will come up with more insightful views and suggestions in the future.

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