



ANALYSIS

A new index reveals a widening gap between growth and sustainable wellbeing in China

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ARTICLE INFO

Keywords:

Wellbeing diversity
Sustainable wellbeing
Decoupling of wellbeing and growth
Genuine progress indicator

ABSTRACT

Previous wellbeing measures often aggregate economic, social, and environmental dimensions, assuming full substitutability. We propose a new index—Sustainable Wellbeing (SW)—that integrates Wellbeing Magnitude (WM) and Wellbeing Diversity (WD). This index reflects that positive wellbeing sources increase SW, with diminishing marginal returns, while negative wellbeing sources decrease SW, with increasing marginal damage. Both diversity and magnitude are integral to the index. This framework is applicable to many wellbeing indices. We demonstrate the application of SW using the Genuine Progress Indicator (GPI) for China, creating a revised Sustainable GPI (SGPI) that incorporates WD. An evaluation across China's 31 provinces from 1985 to 2018 shows a decline in WD, leading to a growing gap between sustainable wellbeing and economic growth. Economic wellbeing has expanded at the expense of environmental quality. The SGPI-to-GDP ratio displays an inverted U-shaped curve, reflecting limited substitutability between economic and environmental wellbeing beyond a certain income threshold. Provinces with stronger service sectors experienced the highest per capita SGPI growth. The wellbeing diversity framework supports balanced development and aligns with the Sustainable Development Goals (SDGs).

1. Introduction

Human wellbeing is a critical criterion for policymaking. The gross domestic product (GDP) has been widely employed as a proxy for the level of national wellbeing (UNU-IHDP and UNEP, 2014). However, GDP can only evaluate the marketed aspects of human wellbeing, ignoring other significant elements (Dasgupta et al., 2015; Drupp et al., 2024; Graham et al., 2018; Jackson, 2016; Sen, 2000; Sterling et al., 2017; Stiglitz et al., 2009). For instance, GDP neglects crucial dimensions of wellbeing such as environmental quality and public health (Costanza et al., 2009; Dolan et al., 2008; Van den Bergh, 2009). By enforcing a single metric of economic growth, it diminishes—and in some cases erodes—the diverse, non-market cultures and ways of life (Escobar, 2011). Thus, the pursuit of GDP growth is structurally

unsustainable (Hickel, 2020). There is a growing consensus about the need to develop an integrated and comprehensive framework for evaluating human wellbeing (Costanza et al., 2016; Costanza et al., 2014; Muller, 2014; Steffen et al., 2015a). Notably, various dimensions of wellbeing have been used in wellbeing indices by scholars from different fields, including economic, social, cultural, and environmental dimensions (Baysal and Sutton, 2024). For example, the Green GDP accounts for the environmental dimension (Hicks, 1946; UN, 1993), and the Genuine Progress Indicator (GPI) accounts for both the environmental and social dimensions (Daly and Cobb, 1989). Fleurbaey (2009) summarizes the main improvements to GDP so far, including the incorporation of non-market aspects of wellbeing, subjective measurement, and the “capability approach” proposed by Amartya Sen (1985). Though these new indices and frameworks expand dimensions, most

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of them still focus on the aggregate magnitude of wellbeing, that is, wellbeing scale. This fails to reflect the structure of wellbeing, namely the diversity of wellbeing dimensions. The simple aggregation assumes that all dimensions are perfect substitutes (Baysal and Sutton, 2024), but sustainable wellbeing requires progress in all wellbeing dimensions at once (Griggs et al., 2013; Nilsson et al., 2016). The “degrowth” advocates a deliberate reduction of the material economy to restore ecological balance, promote equity, and enhance human wellbeing (Hickel, 2021; Kallis, 2011; Martínez-Alier et al., 2010). Costanza et al. (2016) have considered measuring sustainable wellbeing that connects with and complements the SDG dashboard and proposed a hybrid indicator to nonlinearly combine the wellbeing dimensions of economy, society, and nature and view any one of the variables can be a “limiting factor” of achieving SDGs. Although reflecting the overarching goal of a simultaneously prosperous, their approach still fail to depict the structure of sustainable wellbeing. Other notable wellbeing indicators such as Human Development Index (HDI), Better Life Index (BLI), Ecological Footprint (E.F.), Happy Planet Index (HPI), and The Well-Being of Nations, as reviewed by Baysal and Sutton (2024) in their discussion of both traditional and contemporary approaches to assessing human wellbeing, likewise fail to directly capture the balance among different sources of wellbeing. Thus, we propose a new perspective—the diversity of wellbeing dimensions—in evaluating human wellbeing. Wellbeing dimension diversity depicts wellbeing structure. Scale and structure are two indispensable elements for human wellbeing (Graham et al., 2018; Jones and Klenow, 2016; Sterling et al., 2017).

Wellbeing dimension diversity has not been studied previously in this way, but diversity has been an important concept in many areas of both natural science and social science. In natural science, the productivity and resilience of ecosystems are correlated with their biodiversity (Haken, 1977; Isbell et al., 2015). More diverse ecosystems have a broader range of ways to use resources, thus making energy and information transfer pathways more diverse, resulting in stronger resilience to uncertainty and disturbance. As a subsystem of the global ecosystem, the human system follows the same basic logic and principles (Daly, 1990; Derissen et al., 2011; Steffen et al., 2015b). In social science, the diversification of investment is a key technique to reduce risks to reach stable gains (Goetzmann and Kumar, 2008). Wellbeing dimension diversity thus plays a similar, pivotal role in sustainable wellbeing by enhancing the ability to confront and resist shocks.

To fill this gap, we propose a new wellbeing index that integrates scale and structure information. We call this integrated approach the “Wellbeing Diversity Integration Framework”. In a manner analogous to those used in finance for portfolio diversification (Yu et al., 2014) and in biology for biodiversity (Keylock, 2005), this paper build a Wellbeing Diversity (WD) formula firstly. We then combine WD with the aggregate Wellbeing Magnitude (WM) as an integrated index—Sustainable Wellbeing (SW). We view our main contribution as proposing the framework, which acts as an actionable agenda for accounting for wellbeing dimension diversity, and we view the specifics of our method, particularly the functional form of diversity, as first steps to be improved by future work.

This framework is applicable to most existing wellbeing indices as long as the index has no subjective scoring of any wellbeing dimension, without changing their measurement methods or compositions. To provide a demonstration, this paper applies the framework to GPI to take advantage of GPI’s comprehensiveness of the wellbeing dimensions, and thus form a new index Sustainable GPI (SGPI).

Taking China as case, we evaluate WD and SW (SGPI) for China’s 31 provinces from 1985 to 2018 (before the pandemic). Since the Reform and Opening, China has embraced GDP growth as a primary policy goal. However, fast growth has masked structural imbalances. China has largely relied on the economy as the main source of increased wellbeing, while ignoring other wellbeing pillars, such as social and environmental wellbeing. Recently, China has been switching its focus from economic growth to high-quality development, and ambitiously moves forward

toward ecological civilization. The evaluation of WD and SGPI can help manage these processes.

The rest of the paper is organized as follows. Section 2 describes our framework and the related properties. Section 3 shows how to apply the framework to an existing index – Genuine Progress Indicator (GPI), and section 4 presents the results of a case study. Section 5 explores robustness. Section 6 concludes.

2. Wellbeing diversity integration framework

2.1. Wellbeing diversity (WD) and sustainable wellbeing (SW)

There are various wellbeing indices following a similar structure. Briefly, the wellbeing index consists of several accounts, and each account has sub-accounts or components. The aggregate magnitude of wellbeing is the sum (or in the case of unitless indices the weighted average) of the wellbeing over all the sources.

Our framework integrates the diversity of wellbeing dimensions into these indices and produces a new index that combines the magnitude and diversity information. The new index is named Sustainable Wellbeing (SW) because it intends to evaluate the sustainable wellbeing considering the balance degree of the composition of wellbeing. When we believe that the diversity of wellbeing dimensions is important and that the sources of wellbeing are not completely substitutable, we can understand it as: the positive wellbeing sources increase the SW, but the marginal contribution is diminishing. The negative wellbeing sources lessen the SW, and the marginal damage is increasing. For example, climate change has a “tipping point” beyond which any small change in the climate system would cause significant and cascading damages (Lenton et al., 2019). The consideration of negative wellbeing contributors increases the applicability of our framework, since many wellbeing indices have negative wellbeing sources included.

We first measure the diversity of wellbeing dimensions. Guided by these principles and inspired by those used in finance for portfolio diversification (Yu et al., 2014) and in biology for biodiversity (Keylock, 2005), we construct the formula for the diversity of positive wellbeing dimensions (WD_P) as:

$$WD_P = 1 - \frac{1}{2} \sum_{i=1}^I \left(\frac{B_i}{\sum_{i=1}^I B_i} - \frac{1}{I} \right)^2 \tag{1}$$

where B_i denotes the monetary benefit boosted by the i^{th} positive wellbeing source, and I denotes the number of positive wellbeing sources. When $B_1 = B_2 = \dots = B_I$, positive wellbeing sources are perfectly balanced, yielding a maximum WD_P value of one.

Similarly, the diversity of negative wellbeing dimensions (WD_N) is defined as:

$$WD_N = 1 - \frac{1}{2} \sum_{j=1}^J \left(\frac{H_j}{\sum_{j=1}^J H_j} - \frac{1}{J} \right)^2 \tag{2}$$

where H_j denotes the monetary damage induced by the j^{th} negative wellbeing source and J denotes the number of negative wellbeing sources. When $H_1 = H_2 = \dots = H_J$, negative wellbeing sources are perfectly balanced, yielding a maximum WD_N value of one.

Then we further define the imbalance degree (non-diversity) of negative wellbeing dimensions as:

$$WND_N = 1 + \frac{1}{2} \sum_{j=1}^J \left(\frac{H_j}{\sum_{j=1}^J H_j} - \frac{1}{J} \right)^2 \tag{3}$$

which is derived from $WD_N \equiv 2 - WND_N$. The imbalance of negative wellbeing sources would increase their damage to sustainable wellbeing.

The magnitude of positive wellbeing sources and negative wellbeing sources are calculated as:

$$WM_P = \sum_{i=1}^I B_i \tag{4}$$

$$WM_N = \sum_{j=1}^J |H_j| \tag{5}$$

where the WM_P and WM_N represent the total absolute magnitude of the positive and negative wellbeing sources respectively.

Finally, we combine the Wellbeing Magnitude and the Wellbeing Diversity into a unified measure of Sustainable Wellbeing (SW), while keeping absolute magnitude and diversity levels separable within the measure, allowing their distinct contributions to be discerned:

$$SW = WM_P \times WD_P - WM_N \times WND_N \tag{6}$$

2.2. Properties of sustainable wellbeing (SW)

As stated previously, this framework shares some basic economic principles. First, the new index derived from our framework obeys the law of diminishing marginal utility – the marginal contribution of the increment in any positive wellbeing source to the overall sustainable wellbeing is decreasing, and it also obeys the standard pattern of marginal cost – the marginal damage of the increment in any negative wellbeing source to the overall sustainable wellbeing is increasing. Second, the rationale for considering the diversity of wellbeing dimension is the imperfect substitutability among wellbeing sources. This is consonant with the rationale for considering the structure of consumption basket at the micro level. At the micro level, a few consumption goods might be perfect substitutes with each other under certain circumstances, but the macro wellbeing sources (i.e., the three pillars: economic, social and environmental) are unlikely to be perfect substitutes.

Inherence, this framework holds to a principle for both positive and negative wellbeing sources, the more balanced, the better. The properties of this framework are reflected by SW's informative first-order and second-order partial derivatives.

- (1) Property 1: The increment of any positive (negative) wellbeing source results in an increase (decrease) of SW.

The first-order derivative with respect to the magnitude of positive wellbeing source is positive, and the first-order derivative with respect to the magnitude of negative wellbeing source is negative:

Table 1
Full names of the abbreviations in GPI formula.

Personal consumption expenses (CONS)	Income inequality (INEQUAL)*
Services of durable consumer goods (B_{DCG})	Cost of durable consumer goods (C_{DCG})
Net capital growth (CAP) ¹	Cost of underemployment (UE)
Value of domestic labor (LAB)	Cost of family breakdown (BD)
Value of volunteer work (VOL)	Cost of crime (CRIME)
Increase in leisure time (LEIS)	Defensive private expenditure on education & health ($EH_{PV\tau}$)
Non-defensive public expenses on education & health (EH_{PUB})	Cost of commuting (COMM)
Services from public infrastructure (INFRA)	Cost of auto accidents (ACC)
Increase in wetlands (WETL)	Cost of water pollution (WATER)
Increase in forests (FORST)	Cost of air pollution (CO ₂ , SO ₂ , PM) (AIR)
	Cost of solid waste pollution (SOLID)
	Long-term environmental damage (CLIMATE)
	Depletion of non-renewables (NR)
	Cost of natural disaster (ND)

* The consideration of income inequality reflects the inequality of total wellbeing (proxied by total income) across individuals, not reflecting the two-dimensional inequality, that is, who receives what.

$$\frac{\partial SW}{\partial B_i} = 1 + \frac{1}{2I} - P_i + \frac{1}{2} \sum_{i=1}^I P_i^2 > 0 \tag{7}$$

$$\frac{\partial SW}{\partial H_j} = - \left(1 - \frac{1}{2J} + P_j - \frac{1}{2} \sum_{j=1}^J P_j^2 \right) < 0 \tag{8}$$

where $P_i \triangleq B_i / \sum_{i=1}^I B_i$ and $P_j \triangleq H_j / \sum_{j=1}^J H_j$.

The positive (negative) first-order derivative with respect to a positive (negative) wellbeing source is consistent with the fact that the increment of any positive (negative) wellbeing source results in an increase (decrease) of SW.

- (2) Property 2: The diminishing marginal wellbeing from positive wellbeing and the increasing marginal damage from negative wellbeing.

The second-order derivatives with respect to any positive wellbeing source or any negative wellbeing source are both negative:

$$\frac{\partial^2 SW}{\partial B_i^2} = \frac{1}{\sum_{i=1}^I B_i} \left[- (1 - P_i)^2 - \sum_{i \neq i'} P_{i'}^2 \right] < 0 \tag{9}$$

$$\frac{\partial^2 SW}{\partial H_j^2} = - \frac{1}{\sum_{j=1}^J H_j} \left[(1 - P_j)^2 + \sum_{j \neq j'} P_{j'}^2 \right] < 0 \tag{10}$$

The negative second-order derivative with respect to a positive wellbeing source indicates that the marginal increase of SW derived from the increment of a given positive wellbeing source declines, implying the diminishing marginal social wellbeing from positive wellbeing. The negative second-order derivative with respect to a negative wellbeing source indicates increasing marginal damage from negative wellbeing.

Table 2
GPI index system.

Dimension	Positive/negative wellbeing	Component
Economic dimension	Positive wellbeing (B_1)	Personal consumption expenses
		Services of durables
	Negative wellbeing (H_1)	Net capital growth
		Income inequality
Social dimension	Positive wellbeing (B_2)	Cost of durables
		Cost of underemployment
		Net capital decline
		Value of domestic labor
	Negative wellbeing (H_2)	Value of volunteer work
		Increase in leisure time
		Non-defensive public expenses on education and health
		Services from public infrastructure
		Cost of family breakdown
		Cost of crime
Environmental dimension	Positive wellbeing (B_3)	Decrease in leisure time
		Defensive private expenditure on education and health
		Cost of commuting
		Cost of auto accidents
	Negative wellbeing (H_3)	Increase in wetlands
		Increase in forests
		Decrease in wetlands
		Decrease in forests
		Cost of water pollution
		Cost of air pollution (CO ₂ , SO ₂ , PM)
		Cost of solid waste pollution
		Long-term environmental damage
		Depletion of non-renewables
		Cost of natural disaster

Notes: Every item in positive wellbeing parts of each dimension is expressed as a positive number, and the items in negative wellbeing parts are expressed as a negative number.

The implications of the derivatives match the non-linear property of wellbeing – a negative shock on a wellbeing source that is already positively weak or negatively strong would probably cause bigger loss to the overall wellbeing level than an equally big shock on a wellbeing source that is positively strong or negatively weak.

3. Application to genuine progress indicator (GPI)

Genuine Progress Indicator (GPI) is a variant of the Index of Sustainable Economic Welfare (ISEW) initially proposed by Daly and Cobb (1989). GPI is a well-acknowledged wellbeing index and is used by national and local governments (Costanza et al., 2004; Kubiszewski et al., 2013; Posner and Costanza, 2011; Talberth and Weisdorf, 2017).

GPI consists of the economic, social and environmental dimensions, and each dimension has a set of positive and negative components, as illustrated in formula (11) (the full names of the abbreviations are shown in Table 1. Although GPI incorporates social and environmental dimensions alongside economic wellbeing, it loses information on diversity and balance once the components are aggregated, implicitly assuming that human-made capital can substitute for natural capital (Baysal and Sutton, 2024).

$$\begin{aligned}
 \text{GPI} = & \underbrace{\text{CONS} + B_{DCG} + \text{CAP}}_{\text{PositiveEconomicComponents}} - \underbrace{(\text{INEQUAL} + C_{DCG} + \text{UE})}_{\text{NegativeEconomicComponents}} \\
 & + \underbrace{\text{LAB} + \text{VOL} + \text{LEIS} + \text{EH}_{\text{PUB}} + \text{INFRA}}_{\text{PositiveSocialComponents}} - \underbrace{(\text{DBD} + \text{CRIME} + \text{EH}_{\text{PVT}} + \text{COMM} + \text{ACC})}_{\text{NegativeSocialComponents}} \\
 & + \underbrace{\text{WETL} + \text{FORST}}_{\text{PositiveEnvironmentalComponents}} - \underbrace{(\text{WATER} + \text{AIR} + \text{SOLID} + \text{CLIMATE} + \text{NR} + \text{ND})}_{\text{NegativeEnvironmentalComponents}}
 \end{aligned} \tag{11}$$

We apply the Wellbeing Diversity Integration Framework to GPI to illustrate its applicability. The GPI index system we used is shown in Table 2 and the estimation methods for each component are presented in Appendix A.1.

When applied to GPI, the WM in the framework corresponds to GPI, and the SW corresponds to “Sustainable GPI” (SGPI). WD can be computed at the dimension level to measure the balance degree of economic, social, and environmental wellbeing, or computed at the component level to measure the balance degree of all wellbeing components. We compute WD at the dimension level in this paper.

SGPI is then calculated according to formula (6):

$$\begin{aligned}
 \text{SGPI} = & \left(\sum_{i=1}^3 B_i \right) \times \left[1 - \frac{1}{2} \sum_{i=1}^3 \left(\frac{B_i}{\sum_{i=1}^3 B_i} - \frac{1}{3} \right)^2 \right] - \left(\sum_{j=1}^3 H_j \right) \\
 & \times \left[1 + \frac{1}{2} \sum_{j=1}^3 \left(\frac{H_j}{\sum_{j=1}^3 H_j} - \frac{1}{3} \right)^2 \right]
 \end{aligned} \tag{12}$$

4. The case study: the evaluation of China’s wellbeing diversity and sustainable wellbeing

We evaluate the diversity of wellbeing dimension and sustainable wellbeing based on GPI for China’s provinces from 1985 to 2018. The data of each GPI component are collected and calculated from sources such as statistical yearbooks (e.g., provincial, environmental, and energy statistical yearbooks) and surveys (e.g., time use survey). See Appendix A.2 for details.

We begin with the national trend of SGPI in Section 4.1. Next, we summarize the relationship between SGPI and GDP as a “Sustainable

Kuznets Curve” in Section 4.2. Then, we examine industrial heterogeneity in Section 4.3. Lastly, we explore geographical heterogeneity in Section 4.4.

4.1. National trend

Our first finding can be summarized as follows:

KEY POINT 1: China has experienced an increasing imbalance in wellbeing dimensions, leading to a widening gap between “Sustainable GPI” (SGPI) and GDP. This gap is larger than previous estimates that overlooks wellbeing dimension diversity.

Fig. 1 (see provincial results of GPI per capita, WD_P , WD_N , and SGPI per capita in Appendix A.3, Appendix A.4, Appendix A.5, and Appendix A.6 respectively) illustrates this point. From 1985 to 2018, the WD_P trends downwards, indicating a decreasing diversity of positive wellbeing dimensions (Panel A). Although the WD_N trends upward, the overall net wellbeing dimension diversity declines, which can be reflected by the growing dominance of economic wellbeing over environmental wellbeing (Panel B). Economic net wellbeing exhibited a monopolistic increase of 1300 % from 1985 to 2018, whereas net social wellbeing saw a relatively modest gain of 616 %. Contrarily, net environmental wellbeing recorded a 330 % net loss, highlighting a deteriorating diversity.

Excessive emphasis on the economic dimension has instigated a discernible decoupling between the Sustainable GPI (SGPI) and GDP in China. The difference between SGPI per capita and GDP per capita increased from \$443 in 1985 to \$5806 in 2018 (in 2018 dollars). This indicates that sustainable wellbeing growth is lagging behind GDP growth (Panel C). This divergence is more significant than initially anticipated, with the gap between SGPI and GDP widening more than the gap between GPI and GDP. This suggests that overlooking wellbeing dimension diversity may result in an underestimation of the severity of wealth-and-wellbeing decoupling.

4.2. Sustainable Kuznets curve

In this subsection, we explore the relationship between SGPI and GDP. Our second finding is:

KEY POINT 2: The relationship between SGPI and GDP per capita follows an inverted U-shape: as GDP per capita rises, the ratio of SGPI to GDP initially improves but eventually declines. This indicates the limited substitutability between economic and environmental wellbeing after the GDP exceeds a threshold.

Fig. 2 shows a scatter plot of the ratio of SGPI to GDP for each province-year pair against real per capita GDP, along with a fitted curve. At lower levels of GDP per capita, the SGPI-to-GDP ratio increases with rising GDP per capita, reaching a peak at the GDP per capita threshold of \$9025 (in 2018 dollars). Beyond this threshold, the ratio begins to decline as GDP per capita continues to increase. Ninety percent of province-year pairs fall below this threshold, while 10 % pairs are above it, all occurring after 2005. In later years, more provinces surpass this threshold compared to earlier years (see Fig. 3).

This inverted U-shaped relationship indicates that economic wellbeing initially enhances sustainable wellbeing at lower income levels.

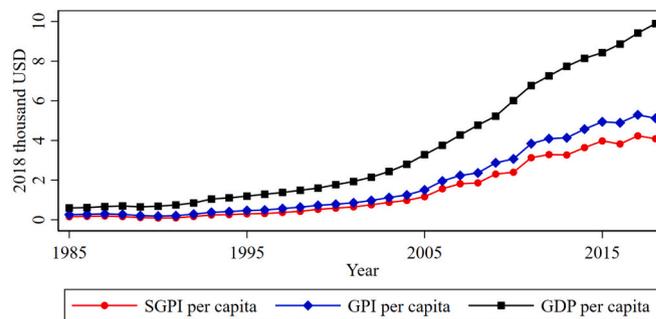
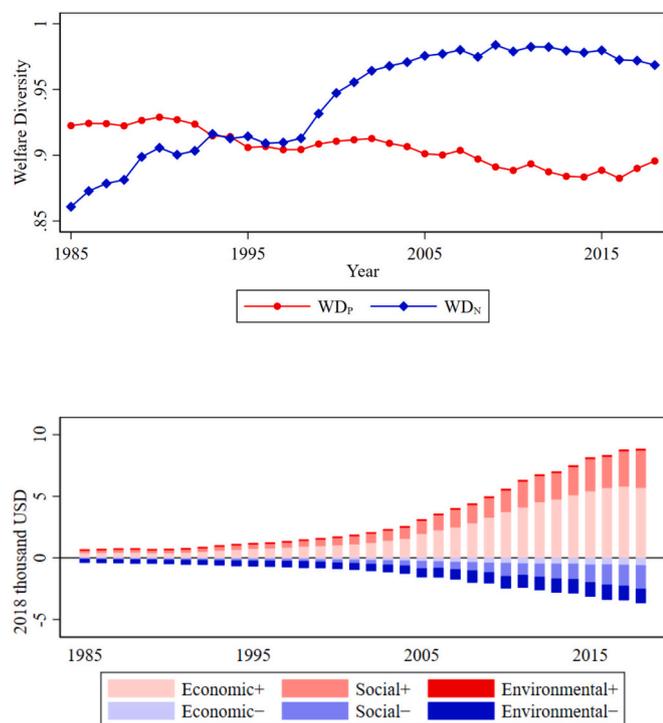


Fig. 1. China's National Sustainable GPI (SGPI) from 1985 to 2018.

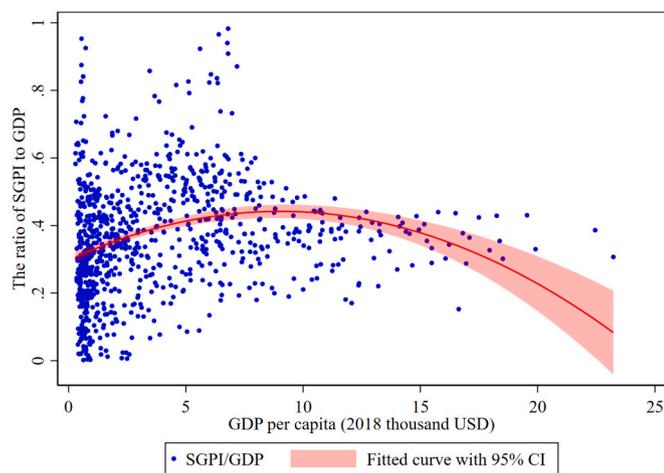


Fig. 2. Sustainable Kuznets Curve—the SGPI-to-GDP ratio displays inverted U-shape.

However, as income continues to rise, the additional GDP gains lead to diminishing or even negative returns in sustainable wellbeing relative to GDP, due to the losses in environmental and social dimensions. This pattern demonstrates the decreasing wellbeing dimension diversity as resources become scarcer due to depletion resulting from economic growth. This finding also echoes the “Threshold Hypothesis” originally proposed by Max-Neef (1995), which states that “There seems to be a period in which economic growth (as conventionally measured) brings about an improvement in life quality, but only up to a point - the threshold point - beyond which, if there is more economic growth, quality of life may begin to deteriorate.”

4.3. Industrial heterogeneity

While the preceding analysis focuses on the general trend and pattern, this section examines the heterogeneity among provinces based

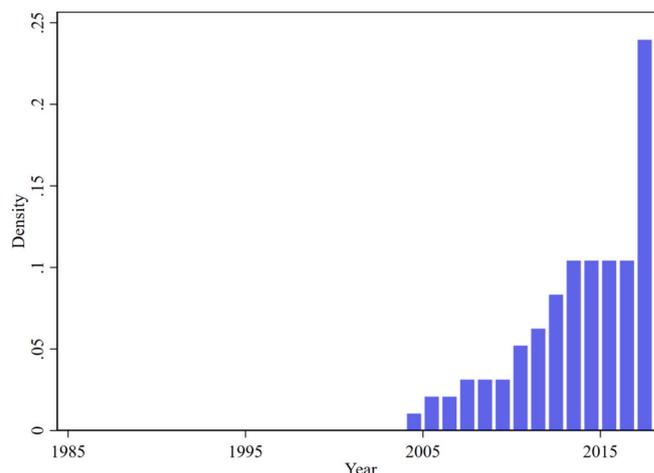


Fig. 3. Density of province-year pairs above the threshold of Sustainable Kuznets Curve by year.

Table 3 Province categorization by dominant sector.

Type	Province
Agriculture	Heilongjiang, Guangxi, Guizhou, Xinjiang, Inner Mongolia, Hebei, Qinghai
Tourism	Hainan, Hubei, Yunnan, Tibet, Sichuan, Hunan, Chongqing, Henan, Anhui
Manufacturing	Shanxi, Jiangsu, Fujian, Shaanxi, Zhejiang, Jiangxi, Ningxia, Shandong
Service	Beijing, Shanghai, Tianjin, Guangdong, Gansu, Jilin, Liaoning

Notes: For each sector (agriculture, tourism, manufacturing, and service), we calculate the ratio of each province's sector GDP to its total GDP. We then rank the provinces by these ratios for each sector. A province is classified based on its highest ranking sector. For example, if a province's highest rank is in agriculture, it is classified as an agriculture province.

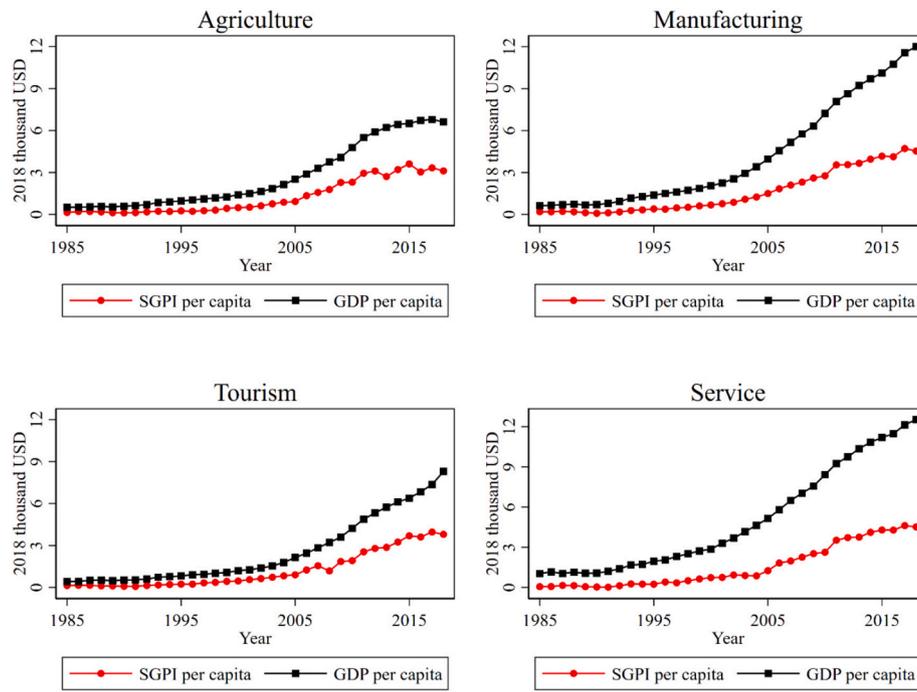


Fig. 4. China's SGPI per capita and GDP per capita of provinces categorized by dominant sector, 1985–2018.

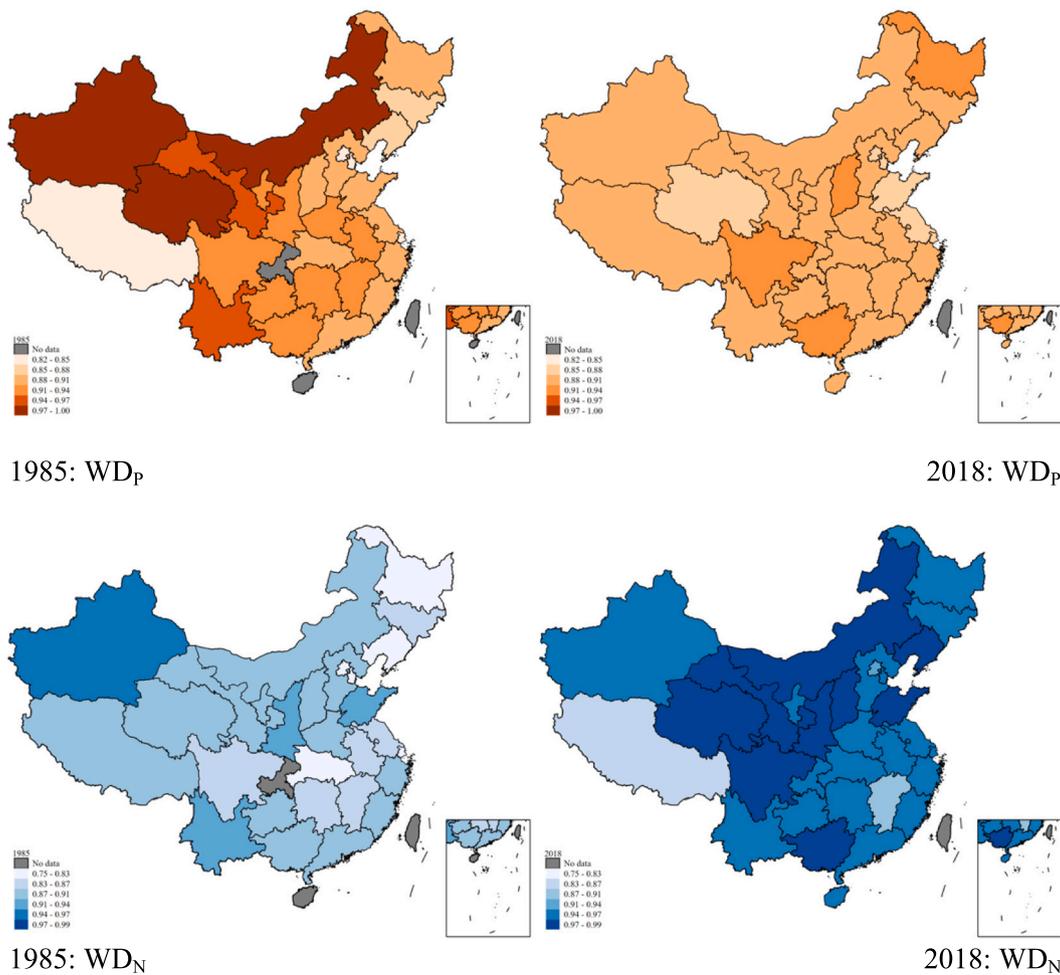


Fig. 5. Provincial wellbeing diversity.

on their industrial structures. Table 3 categorizes provinces into four groups based on their dominant sectors: agriculture, tourism, manufacturing, and service.

Fig. 4 compares SGPI per capita and GDP per capita across four types of provinces. First, all province types show an upward trend in SGPI per capita, particularly after 2005. Manufacturing provinces saw an earlier increase starting from 2002, likely due to China’s accession to the World Trade Organization in December 2001. In agricultural provinces, SGPI per capita stagnated after 2011 with some fluctuations, while other province types continued to see increases. Service provinces saw the largest percentage increase of 14.2 % from 1985 to 2018, while other provinces increased by only 9.8–10.6 % over the same period.

Second, provinces dominated by manufacturing or service sectors exhibit higher SGPI per capita than those dominated by agriculture or tourism. In 2018, the average SGPI per capita is \$4538 in manufacturing provinces, \$4521 in service provinces, \$3796 in tourism provinces, and \$3114 in agricultural provinces. Agricultural and tourism provinces have low SGPI per capita due to their low economic wellbeing, with their GDP per capita in 2018 being only 52.8 % and 66.2 %, respectively, of that in service-dominated provinces. In sum, we summarize the results as follows:

KEY POINT 3: Provinces dominated by service sector show highest sustainable wellbeing, while agricultural and tourism provinces need more economic wellbeing to boost their sustainable wellbeing.

4.4. Geographical heterogeneity

We first present the across-province heterogeneity in Section 4.4.1 and then within-province heterogeneity in Section 4.4.2. The key finding from this section is:

KEY POINT 4: The across-province heterogeneity in SGPI has increased over time, but to a lesser extent than GDP. This is because provinces with high GDP per capita also bear high environmental costs, reducing their advantages when measured by SGPI. Within-province heterogeneity is more significant in the northern region because of the high within-province variation in resource endowment.

4.4.1. Across-province heterogeneity

As shown in Fig. 5, in 1985, the northern and western provinces had a higher diversity of positive wellbeing components (WD_p) compared to the eastern provinces. However, this advantage was eroded over time as economic wellbeing increasingly dominated sustainable wellbeing, leading to a geographical convergence in WD_p by 2018. In contrast to this convergence, the diversity of negative wellbeing components (WD_N) displayed a divergent pattern over the same period. The northeastern provinces saw an increase in WD_N , with losses more evenly distributed

across the economic, social, and environmental components.

The historical trends of GPI per capita, WD_p , WD_N and SGPI per capita also show geographical divergence, which is illustrated in Appendix A.7. Some provinces experienced significant changes due to various reasons, such as the Beijing Olympic, SARS pandemic, and Wenchuan earthquake (see Appendix A.8 for details).

We further examine the heterogeneity in GDP, GPI, and SGPI across provinces. Fig. 6 shows the across-province standard deviations. All measures exhibit increasing standard deviations over time, indicating growing heterogeneity. In 1985, the standard deviations were similar, but GDP’s standard deviation grew the fastest. By 2018, GDP’s standard deviation was 2.5 times that of SGPI, suggesting that rapid economic growth in some provinces does not result in equivalent sustainable wellbeing growth. This is because that provinces with high GDP per capita also bear high environmental costs, reducing their advantages when measured by SGPI. The environmental costs per capita in

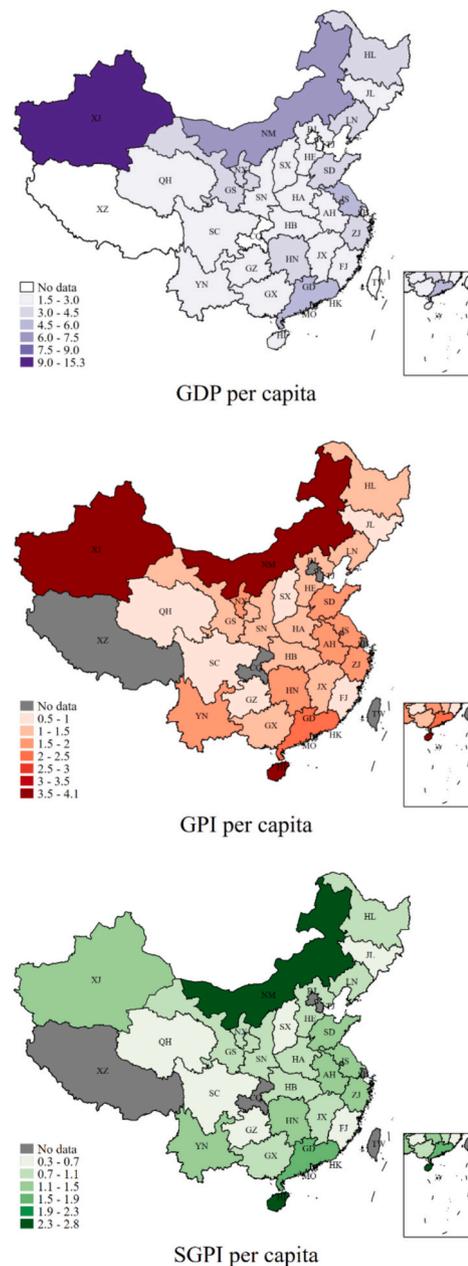


Fig. 7. Within-province standard deviation of GDP, GPI and SGPI per capita. Note: GDP per capita, GPI per capita and SGPI per capita are averaged over the 1985–2018 period before calculating the standard deviation.

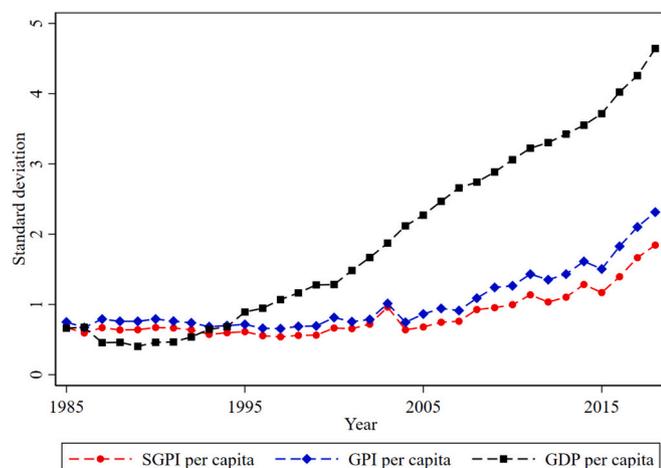


Fig. 6. Across-province standard deviation of GDP, GPI and SGPI per capita.

provinces with GDP per capita above the median are 54 % higher than in those below the median.

4.4.2. Within-province heterogeneity

Even within a given province, significant heterogeneity exists. For example, in Inner Mongolia, the highest GDP per capita at the prefecture level is more than three times the lowest. To capture this variation, we estimate the within-province standard deviation for GDP, GPI and SGPI. As Fig. 7 shows, all three measures exhibit a similar pattern that the northern province (Inner Mongolia (NM)) displays the largest within-province heterogeneity. This is due to the uneven distribution of natural resources. Cities in Inner Mongolia like Ordos and Baotou, rich in coal and minerals, have experienced rapid growth driven by resource extraction industries, while cities lacking such resources have lagged behind. Xinjiang (XJ) shows a large within-province heterogeneity in GDP, but this is alleviated in SG due to the great environmental costs (e. g., resource depletion and water pollution) resulting from economic growth in several prefectures such as Karamay.

5. Robustness

We acknowledge the debate regarding component selection and estimation methods for GPI. We conduct sensitivity analysis to examine how different component selections and estimation methods influence the SGPI assessments and the baseline results.

5.1. Component selection

First, we consider the potential for missing and redundant components. All components considered in the GPI or ISEW literature and exhibiting high data quality are included in our assessment, eliminating the risk of missing components. For redundant components, we exclude the cost of underemployment, the cost of natural disasters, and the (negative) defensive private expenditure on health and education. The rationale behind removing natural disaster costs and underemployment costs was that other components of GPI, such as personal consumption expenditures and services from durable goods, already accounted for the utility lost by natural disaster and underemployment (Talberth and Weisdorf, 2017). The rationale for removing the negative defensive private expenditure on health and education is that spending on health to extend life allows individuals to purchase additional periods of utility (Hall and Jones, 2007). Results are shown in Appendix A.9. The main findings from the baseline still hold.

5.2. Component estimation

We use alternative estimation methods for four wellbeing components. First, there are two indices for income inequality – the Atkinson index and the Gini index. We use Atkinson index in the baseline results, and the Gini index in this sensitivity analysis. Although the Gini index measures the relative income inequality, making the GPI hard to compare with the absolute level of GDP (Long and Ji, 2019), it has been applied by a large body of research (Gigliarano et al., 2014; Kubiszewski et al., 2013; Kubiszewski et al., 2015; Menegaki and Tsagarakis, 2015; O'Mahony et al., 2018).

Second, the cost of non-renewables depletion is estimated by the replacement costs method, and a constant replacement cost (i.e., zero escalation) is applied in the baseline results. There is a debate about the cost escalation factor in the replacement costs method. In the sensitivity analysis, we employ an escalation factor of 3 %, following the practices in many studies, including Neumayer (2000).

Third, commuting cost includes the economic cost (non-recreational expenditure on transportation) and the cost of time. In the baseline results, the cost of time is commuting time multiplied by the wage rate, as suggested by Costanza et al. (2004). In the sensitivity analysis, the cost of time is the product of commuting time and half of the wage rate,

following Small (2012) and Wolff (2014).

Fourth, we use different unit costs of wastewater. In the baseline results, the unit cost of waste water is estimated by Yang et al. (2014), not distinguishing the type of pollutants. In the sensitivity analysis, the new unit cost of wastewater is the sum of costs of COD (Chemical Oxygen Demand) and Ammonia-Nitrogen Emission per unit of wastewater. The cost of COD per unit waste water is the product of the volume of COD per unit waste water and unit cost of COD (Hernandez-Sancho et al., 2010), and the same logic is applied to Ammonia-Nitrogen Emission.

Among the four alternative methods explored in the sensitivity analysis, the most significant impact on results is observed when altering the estimation method for income inequality, but all main findings still hold (Appendix A.10).

6. Concluding remarks

6.1. Conclusions

Existing studies focus on adding dimensions and components to wellbeing measurement. Such efforts improve the measurement of wellbeing magnitude, but they ignore the diversity of wellbeing dimensions. This paper opens up a new perspective by highlighting that the diversity of wellbeing dimensions is critical when evaluating sustainable wellbeing, because it is an important indicator of the stability and resilience of human system. We propose a wellbeing dimension diversity integration framework that produces a unified wellbeing index “Sustainable Wellbeing” that integrates Wellbeing Magnitude and Wellbeing Diversity.

There are three advantages of the framework. First, evaluating WD enables us to assess the balance and stability of wellbeing sources. Second, the framework produces an integrated wellbeing index that reflects both Wellbeing Magnitude (WM) and Wellbeing Diversity (WD) information. Third, the proposed framework is applicable to most existing wellbeing indices as long as the index has no subjective scoring of any wellbeing dimension, without changing their measurement methods or compositions.

We employ the framework using China's GPI as an illustration. We find that China's WD of positive wellbeing dimensions showed a fluctuating decline during the past 30 years, and the WD of negative components also decreased after 2006. The worsened wellbeing structure led to an increasing decoupling trend between sustainable wellbeing and economic growth. The decline in WD could be mainly attributed to the dominance of the contribution from economic wellbeing components and the increasing environmental costs. To explore the relationship between SGPI and GDP per capita, we find that the SGPI-to-GDP ratio follows an inverted U-shape as GDP per capita rises, which indicates the limited substitutability between economic and environmental wellbeing after the GDP exceeds a threshold. What's more, provinces dominated by service sector show highest sustainable wellbeing and large heterogeneity also exists geographically within China, which demonstrates the unbalanced development in China.

6.2. Policy implication

We measure Wellbeing Diversity as an indicator of resilience and sustainability. Although not capturing all the factors that contribute to resilience and sustainability, the combined indicator of magnitude and diversity is a better indicator of sustainable wellbeing than wellbeing magnitude alone. The insights gained from the framework's application to China supports the feasibility of this framework in estimating resilience and sustainability. The fast economic growth since the Reform and Opening has masked structural imbalances in China, with 10 % of province-year pairs surpass the GDP per capita threshold of \$9025 (in 2018 dollars) beyond which the SGPI-to-GDP ratio begins to decline. Our evaluation of WD and SW indicates that China should speed up the

process of switching from economic growth to high-quality development. In densely populated and economically advanced regions that have already reached substantial scale, policy priorities should shift from promoting further expansion to improving population quality and optimizing economic structures. Investment should likewise be reoriented from quantitative growth toward enhancing ecological quality and social equity. The principle of “macro-level scale control with micro-level market freedom” should guide this transition. Governments can set regulatory frameworks such as “ceilings,” “red lines,” and “baselines,” while leveraging both quantity-based instruments (e.g., property rights trading) and price-based instruments (e.g., taxes and fees) to create incentives and constraints (as emphasized by Ji et al. (2022)). Even in less developed regions that have yet to reach the scale threshold, traditional growth models should be abandoned in favor of green development. Indeed, China’s broader social transformation toward an ecological civilization is already advancing in this direction. Furthermore, it also shows its potential advantages in promoting the global realization of the Sustainable Development Goals (SDGs). The SDGs set out an ambitious vision in which the three dimensions of sustainable development – the economic, social, and environmental dimensions – are intended to be balanced. Advancements in all three dimensions in a balanced way can ensure a more resilient and sustainable future.

The new index and the findings also guide us to balance structure when approaching the limit of the scale of our planet - the “planetary boundaries” (Rockström et al., 2009). When scale (e.g., population scale, scale of a given sector, wellbeing scale from a given source, etc.) is small, scaling up should be considered as a priority. Local government could focus on enacting expansionary zoning policies, attracting investments, and creating employment opportunities to attract newcomers. When the further increase in scale does not significantly improve net benefits any longer, improving the structures should be made the priority. Policies that cap the scale at a proper level and promote optimal structure, just as Herman E. Daly indicates in his steady-state economy theory (Daly, 2014), are crucial to human wellbeing. When it comes to limiting scale, policies such as cap-and-trade is an option, under which the resources can be allocated efficiently to achieve an optimal structure. The transition to a sustainable society requires addressing structural imbalances, so policies targeting population

Appendix A. Appendix

A.1. Estimation of GPI

GPI should be an index that is temporally and regionally sensitive, constantly adjusted to accommodate the current needs. All the components that were considered in ISEW or GPI literature and that have good data quality are included in the assessment. One new component, the health costs of particulate pollution, which have not been considered in literature yet but emerge recently in developing countries like China is added into the GPI assessment. The estimation methods for each component are presented below.

Dimension	Item	Method
Economic Dimension	Personal Consumption Expenditures	Personal consumption expenditure is the starting point of GPI calculation. An increase in personal consumption expenditures brings an improvement in wellbeing. Data are obtained from statistical yearbooks.
	Income Inequality	We apply Atkinson index to measure the income inequality. Following Latty (2011), we choose the value of society’s aversion to inequality to be 1.5. Detailed calculation can be found in Long and Ji (2019).
	Services of Consumer Durables	We assume that the average service life of consumer durables is eight years, so the depreciation rate is 12.5 % per year. $Services\ of\ Consumer\ Durables = Cost\ of\ Consumer\ Durables \times Depreciation\ rate$
	Cost of Consumer Durables	Since Services of Consumer Durables is included, its cost should be deducted to avoid double counting. Data are obtained from statistical yearbooks.
	Cost of Underemployment	Cost of underemployment is measured with wage rate (Costanza et al., 2004). $Cost\ of\ Underemployment = Number\ of\ underemployed \times Unprovided\ hours\ per\ worker \times Hourly\ wage$ China’s statistical yearbooks contain only registered urban unemployment. Data on rural and unregistered unemployment are not collected. The cost of underemployment is therefore underestimated.

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structure, industrial structure, consumption structure, and trade structure should be considered.

6.3. Future research

One immediate extension would be to apply the framework to more regions and countries, to examine and compare the welfare structure and SW beyond China. Another research area is to improve the specific formulas of SW. This paper aims at providing a guideline for planners and researchers to measure wellbeing diversity and evaluate policies considering wellbeing diversity. Planners and researchers can customize the specific formulas based on their information of the social preference and risk aversion. For example, if the information suggests that different welfare dimensions have the constant elasticity of substitution (CES) relation, they can adopt the CES-based formula proposed in the Method section, with their specific elasticity parameter.

CRedit authorship contribution statement

Xi Ji: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Xianling Long:** Writing – review & editing, Writing – original draft, Methodology, Investigation. **Xuanyuan Luo:** Writing – original draft, Software, Methodology, Formal analysis, Data curation. **Robert Costanza:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research is jointly supported by the National Natural Science Foundation of China (grant No. 71973008) and the Major Special Program of Social Science Foundation of China (grant No. 22VMG017).

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Dimension	Item	Method
		<p>Net Capital Growth is the difference between newly added capital investment and the human capital required for such increment. The calculation formula is:</p> $NCl = (K - K_{-1}) - \frac{L - L_{-1}}{L} \times K_{-1}$ <p>where K is the capital stock of the current period, K_{-1} the stock of the previous period, L human capital in the current period, L_{-1} the human capital period in the previous period.</p> <p>Capital stock is not reported in any official statistical yearbooks, so the Perpetual Inventory Method based on each year's capital investment is employed to estimate the capital stock. The calculation formula is:</p> $NK_t = (1 - \delta)^t \times NK_0 + \sum_{k=1}^t (1 - \delta)^{t-k} \Delta_k$ <p>where NK_t represents the capital stock of period t, δ the consumption rate (depreciation rate) of fixed capital, NK_{t-1} capital stock of period $t-1$, NK_0 capital stock of the base period, Δ_k the fixed capital formation of period k adjusted by price index of investment in fixed asset. According to Shan (Shan, 2008), the average depreciation rate of fixed asset is 10.96%. Capital stock at the base year is calculated from the formula below:</p> $NK_t = I_t / (\delta + g_t)$ <p>where I_t represents fixed capital formation in period t, g_t the average capital growth rate or output growth rate including period t. Here the average growth rate of capital investment between year 1996 and 1998 is chosen as average capital growth rate.</p>
	Net Capital Growth	
	Cost of Water Pollution	<p>Data on the amount of wastewater are obtained from statistical yearbooks. The unit cost of wastewater is estimated by Yang et al. (2014).</p> <p>Cost of air pollution includes the environmental cost of SO₂, NO_x, Total Suspended Particles (TSP), CO₂, and PM. Emission: Emissions of SO₂ and TSP are directly obtained from statistical yearbooks, but the emission of CO₂ is not reported in any official statistics. We calculate CO₂ emissions based on emission factor of CO₂ and energy use, where the emission factor is estimated by Liu et al. (2015). Data on nitrogen oxides are unavailable. Although it can be estimated using emission factors and energy use, the calculation requires energy use by industry and by energy, which is also unavailable. We ignore the cost of nitrogen oxide.</p> <p>Particulate pollution: Limited by data availability, we choose PM10 (particulate matter 10 μm or less in diameter) as the indicator of particulate pollution at the provincial level and PM2.5 at the prefectural level. We estimate the health costs of particulate pollution using the formula:</p> $C_{it} = h \times M_{it} \times P_{it}$ <p>where C_{it} denotes the total health costs of particulate pollution in region i at year t, h is the unit health cost per capita per μg/m³ of PM, M_{it} the PM concentration and P_{it} the population.</p> <p>Unit cost: Unit environmental cost of SO₂ and TSP estimated by Guo (2006) is applied (SO₂: 1250/t CNY, TSP: 109/t CNY). The unit environmental cost of CO₂ estimated by Liang et al. (2015) is applied (the average cost between year 1992 and 2012 is \$7.28/t). Unit cost of PM₁₀ in China is calculated by dividing the total health costs computed in Zhang et al. (2008) by the population and PM₁₀ concentration while that of PM_{2.5} is calculated according to Yao et al. (2020).</p>
	Cost of Air Pollution	
Environmental Dimension	Cost of Solid Waste Pollution	<p>Solid waste includes household solid waste and industrial solid waste. The latter includes general industrial solid waste disposal, general industrial solid waste storage, hazardous industrial solid waste disposal and hazardous industrial solid waste storage.</p> <p>Imputed cost of solid waste treatment estimated by Gong (2008) is chosen as the unit cost. Unit cost of general industrial solid waste disposal: 75/t CNY, general industrial solid waste storage: 15/t CNY, hazardous industrial solid waste disposal: 1500/t CNY, hazardous industrial solid waste storage: 300/t CNY. Unit cost of household solid waste is 27/t CNY.</p>
	Change of Wetlands	The unit cost of wetland loss estimated by Costanza et al. (1997) (\$14,785/ha) is used.
	Change of Forest	The unit cost of forest loss estimated by Costanza et al. (1997) (\$969/ha) is used.
	Long-term Environmental Damage	<p>Following Cobb and Cobb (1994) and due to a lack of data on carbon emissions at provincial level in China, we employ the fuel tax approach. We value the long-term environmental damage caused by greenhouse gas emissions using fuel tax as a proxy for environmental damage and multiplying it by fuel consumption. We convert the consumptions of all fossil fuels (coal, oil, and natural gas) into equivalent oil consumption. To avoid the problematic accumulation or multiply counting of the environmental damages, we annualize the present value of total future damages to each year at discount rate 3% (Carbon, 2010), giving the damage curve from Ackerman and Stanton (2012). Following O'Mahony et al. (2018) which is applying the same damage curve in Ackerman and Stanton (2012), the annual damage is assumed to increase at a compound growth rate of 1.9837% per year.</p> <p>Replacement costs method is employed. We use the price of non-renewable resources as the replacement costs. Since the historical price of non-renewable resources in China is unavailable, we refer to the historical price in the US. The replacement costs of each nonrenewable in the base year are: oil, \$17.23/barrel; coal, \$18.14/t; natural gas, \$3.66/kCF.</p>
	Depletion of Non-Renewables	
	Cost of Natural Disasters	Data are obtained from statistical yearbooks.
	Value of Domestic Work	Average time spent on housework and parenting are obtained from statistical yearbooks. The unit value of domestic work is measured by the wage rate of domestic service. Only the population in age 15–64 is considered.
	Cost of Family Breakdown	<p>Cost of family breakdown is the unit cost of each divorce multiplied by the number of divorces. According to Costanza et al. (2004), the unit cost of each divorce is \$8922/ divorce plus \$13,380/child. According to Wen et al. (2007), about 0.8599 child is involved in each divorce in China, so the unit cost of divorce in China is \$20,427.</p> <p>Chen and Liu (2013) estimated the total social cost of all crimes in China from year 1997 to 2010, which is approximately increasing by 100 billion CNY per year, so we assume that it continues to increase by 100 billion CNY between year 2011 and 2014. Cost of crime by province is the national crime cost by Chen and Liu (2013) multiplied by the share of crime by province.</p> $\text{Cost of Crime} = \text{National crime cost} \times \frac{\text{Provincial number of crimes}}{\text{National number of crimes}}$
Social Dimension	Cost of Crime	
	Value of Volunteer Work	The calculation is similar to that of value of domestic work.
	Change of Leisure Time	The wellbeing change of leisure time is the change of leisure time multiplied by the unit value of leisure. Wage rate is used as a proxy for unit value of leisure.
	Non-defensive Public Expenses on Education and Health	Public expense on education and health can improve wellbeing. It is the bill the government pays for its residents, as a supplement to personal consumption expenditures. A part of the public expense on education and health, which is defensive, does not promote public wellbeing, so it should be excluded (Tiezzi and Guenno, 1998). Referring to

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Dimension	Item	Method
		<p>Pulselli et al. (2006) and Bleys (2008). 50 % of the expense is considered as non-defensive.</p> <p>Public expense includes central government expenditure and local government expenditure. Since there is no data on the distribution of central government expenditure across provinces, we estimate the non-defensive public expenses on education and health as:</p> <p><i>Non defensive Public Expenses on education and health</i></p> $= \left(E_p + H_p + \frac{E_p}{\sum_{p=1}^{31} E_p} \times E_c + \frac{H_p}{\sum_{p=1}^{31} H_p} \times H_c \right) \times 50\%$ <p>where E_p represents provincial government expenditure on education, H_p provincial government expenditure on health, E_c central government expenditure on education and H_c central government expenditure on health.</p> <p>Part of personal expenditure on education and health that is defensive should be excluded from personal consumption expenditure. The share of defensive private expenditure on education and health in all private expenditure on education and health is also estimated to be 50%.</p> <p>The value of public infrastructure is mainly about transportation. Like public educational/health expense, the wellbeing improvement brought by public infrastructure is government's payment for its residents, which is not included in personal consumption expenditure but should be considered.</p> <p>The value of public infrastructure is annualized public expenditure on public infrastructure during its service life (Costanza et al., 2004). Since data on service life are unavailable, and there is little difference of the expenditure on public infrastructure over time, we can approximate the value simply using each year's expenditure.</p> <p>Expenditure on public infrastructure includes local government expenditure and central government expenditure. Since there is no data on the distribution of central government expenditure across provinces, we estimate the public expenses on public infrastructure as:</p> $\text{Services from Public Infrastructure} = \left(PI_p + \frac{PI_p}{\sum_{p=1}^{31} PI_p} \times PI_c \right)$ <p>where PI_p represents provincial government expenditure on public infrastructure, and PI_c represents central government expenditure on public infrastructure.</p> <p>Cost of commuting includes the economic cost (non-recreational expenditure on transportation) and the cost of time. The economic cost, which is included in personal consumption expenditure, should be deducted, because it does not contribute to wellbeing. Following Cobb and Cobb (1994), the economic cost of commuting is calculated as:</p> $\text{Direct cost of commuting} = 0.3(A - 0.3A) + 0.3B$ <p>where A denotes the private expenditure on transportation. 0.3 A denotes the estimated cost of depreciation of private cars. 0.3 A is deducted to avoid double counting because it has already been included in the cost of consumer durables. 0.3 is the portion of total non-commercial private vehicle miles used in commuting. B is private expenditure on local public transportation. 0.3 is the portion of passenger miles on local public transportation used for commuting.</p> <p>The cost of time should be deducted as well since it negatively affects wellbeing. The cost of time is commuting time multiplied by wage rate (Costanza et al., 2004).</p> <p>Costs of auto accidents are obtained from statistical yearbooks. Since only economic costs are considered, this item is underestimated.</p>
	Defensive Private Expenditure on Health and Education	
	Services from Public Infrastructure	
	Cost of Commuting	
	Cost of Auto Accidents	

A.2. Data sources of indicators of GPI

Dimension	Component	Data source
Economic Dimension	Personal consumption expenditures	Statistics yearbook of China, provincial statistics yearbook
	Income inequality	Statistics yearbook of China, provincial statistics yearbook
	Services of consumer durables	Statistics yearbook of China, provincial statistics yearbook
	Cost of consumer durables	Statistics yearbook of China, provincial statistics yearbook
	Cost of underemployment	China population and employment statistics yearbook, China labor statistical yearbook, provincial statistics yearbook
	Net capital growth	Statistics yearbook of China, provincial statistics yearbook
	Value of domestic work	Data compilation on time use in 2008, statistics yearbook of China
	Cost of family breakdown	Statistics yearbook of China
	Cost of crime	Statistics yearbook of China
	Value of volunteer work	Data compilation on time use in 2008, statistics yearbook of China
Social Dimension	Change of leisure time	China labor statistical yearbook, international statistical yearbook, statistics yearbook of China
	Non-defensive public expenses on education and health	Statistics yearbook of China, finance yearbook of China, provincial statistics yearbook
	Defensive private expenditure on health and education	Statistics yearbook of China, provincial statistics yearbook
	Services from public infrastructure	Statistics yearbook of China, finance yearbook of China
	Cost of commuting	Statistics yearbook of China, data compilation on time use in 2008
	Cost of auto accidents	Statistics yearbook of China
	Cost of water pollution	Statistics yearbook of China, China's environmental yearbook, provincial statistics yearbook
	Cost of air pollution	Statistics Yearbook of China, China's environmental yearbook, China Energy Statistical Yearbook, Atmospheric Composition Analysis Group.
	Cost of solid waste pollution	China's environmental yearbook, China's environmental statistics yearbook, China urban construction statistical yearbook, statistics yearbook of China, provincial statistics yearbook
	Change of wetlands	China forestry statistical yearbook
Environmental Dimension	Change of forest	China forestry statistical yearbook
	Long-term Environmental damage	China energy statistical yearbook
	Depletion of non-renewables	China energy statistical yearbook
	Cost of natural disasters	Statistics yearbook of China, China civil affairs' statistical yearbook

A.3. GPI per capita by Province, 1985–2018 (2018 Thousand US Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	0.469	0.598	0.671	0.525	0.201	0.151	-0.061	-0.096	0.217	0.111	1.171	1.065	0.940	1.734	1.605	1.942	2.309
Tianjin	0.632	0.597	0.482	0.500	0.303	0.264	0.380	0.484	0.462	0.556	0.555	0.982	1.013	1.402	1.368	1.650	1.565
Hebei	0.285	0.253	0.279	0.280	0.211	0.221	0.221	0.308	0.341	0.383	0.483	0.457	0.673	0.680	0.835	0.810	0.901
Shanxi	0.299	0.242	0.205	0.080	0.056	0.058	0.103	0.160	0.203	0.136	0.092	0.001	-0.061	-0.001	-0.040	0.156	0.150
Inner Mongolia	0.569	0.518	0.480	0.495	0.419	0.424	0.421	0.427	0.487	0.515	0.577	0.411	0.465	0.446	0.578	0.611	0.731
Liaoning	0.147	0.179	0.226	0.216	0.082	0.034	0.080	0.145	0.323	0.228	0.017	0.201	0.244	0.380	0.383	0.386	0.581
Jilin	0.309	0.301	0.342	0.252	0.147	0.201	0.179	0.237	0.368	0.358	0.129	0.529	0.419	0.630	0.650	0.630	0.850
Heilongjiang	-0.178	0.234	0.243	0.172	0.076	0.045	0.080	0.167	0.298	0.314	0.282	0.412	0.311	0.417	0.701	0.782	0.821
Shanghai	-0.064	0.091	0.223	0.315	0.192	0.016	0.085	0.306	0.933	1.231	1.696	1.532	1.848	2.049	2.444	3.394	2.346
Jiangsu	0.327	0.295	0.380	0.370	0.248	0.049	0.113	0.344	0.530	0.596	0.867	0.892	0.962	1.045	1.143	1.153	1.238
Zhejiang	0.337	0.347	0.411	0.406	0.302	0.243	0.353	0.352	0.687	0.751	1.047	1.080	1.124	1.192	1.156	1.101	1.350
Anhui	0.262	0.289	0.301	0.253	0.212	0.188	-0.014	0.202	0.299	0.333	0.403	0.396	0.483	0.516	0.537	0.615	0.699
Fujian	0.261	0.294	0.297	0.319	0.279	0.246	0.353	0.493	0.654	0.783	0.927	1.023	1.128	1.230	1.239	1.253	1.291
Jiangxi	0.177	0.169	0.173	0.128	0.105	0.117	0.145	0.176	0.176	0.213	0.193	0.365	0.372	0.260	0.514	0.616	0.704
Shandong	0.351	0.368	0.403	0.363	0.285	0.277	0.324	0.375	0.426	0.552	0.466	0.348	0.659	0.760	0.920	0.994	1.125
Henan	0.229	0.253	0.242	0.198	0.184	0.163	0.191	0.219	0.247	0.325	0.358	0.449	0.436	0.489	0.492	0.456	0.706
Hubei	0.181	0.176	0.167	0.052	0.065	-0.067	-0.042	0.057	0.143	0.174	0.265	0.376	0.451	0.411	0.548	0.608	0.700
Hunan	0.146	0.150	0.187	0.152	0.069	0.127	0.170	0.224	0.303	0.286	0.312	0.230	0.406	0.356	0.582	0.692	0.714
Guangdong	0.327	0.339	0.397	0.477	0.411	0.392	0.394	0.659	0.838	0.892	1.076	1.125	1.062	1.116	1.290	1.133	1.191
Guangxi	0.151	0.179	0.154	0.122	0.091	0.088	0.128	0.179	0.256	0.138	0.277	0.207	0.300	0.313	0.377	0.372	0.342
Hainan				0.362	0.358	0.436	0.371	0.648	0.695	0.836	0.778	0.586	0.350	0.671	0.596	0.399	0.551
Chongqing													0.642	0.704	0.524	0.660	0.772
Sichuan	0.181	0.195	0.206	0.193	0.180	0.195	0.218	0.204	0.206	0.268	0.303	0.264	0.407	0.514	0.602	0.601	0.674
Guizhou	0.232	0.238	0.220	0.174	0.136	0.134	0.155	0.170	0.220	0.222	0.251	0.338	0.201	0.248	0.374	0.445	0.452
Yunnan	0.250	0.271	0.296	0.304	0.259	0.300	0.365	0.398	0.442	0.429	0.375	0.465	0.498	0.603	0.701	0.635	0.602
Tibet	4.148	3.806	4.480	4.343	4.304	4.454	4.275	4.192	3.921	3.935	3.803	3.542	3.502	3.553	3.578	3.875	4.083
Shaanxi	0.285	0.312	0.305	0.299	0.235	0.234	0.234	0.237	0.286	0.300	0.288	0.308	0.373	0.451	0.497	0.613	0.735
Gansu	0.254	0.307	0.277	0.246	0.218	0.165	0.193	0.210	0.119	0.183	0.136	0.230	0.199	0.257	0.395	0.413	0.438
Qinghai	1.112	1.018	1.086	1.047	0.858	0.742	0.913	0.942	1.027	0.977	0.959	1.114	1.057	1.099	1.116	1.199	1.415
Ningxia	0.314	0.367	0.289	0.245	0.128	0.135	0.154	0.147	0.149	0.142	0.116	0.157	0.179	0.393	0.370	0.595	0.751
Xinjiang	0.566	0.568	0.512	0.516	0.453	0.480	0.444	0.511	0.491	0.545	0.497	0.394	0.308	0.698	0.512	0.860	0.704
China	0.260	0.279	0.300	0.273	0.212	0.190	0.208	0.286	0.377	0.413	0.469	0.494	0.567	0.639	0.729	0.787	0.859

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beijing	2.063	2.355	0.129	3.538	3.715	4.703	3.010	4.040	4.286	5.069	5.635	6.103	6.620	6.616	7.992	9.522	10.453
Tianjin	1.805	1.940	2.126	2.604	2.791	2.614	4.214	5.876	5.708	7.506	7.357	7.788	8.712	8.317	8.111	8.909	7.398
Hebei	0.907	1.370	1.653	1.747	2.277	2.472	3.006	3.349	3.158	3.877	3.700	2.901	3.314	3.406	3.306	4.002	3.724
Shanxi	0.257	0.199	0.413	0.746	1.052	1.196	1.374	2.164	2.091	2.584	2.310	2.618	2.851	3.239	2.284	2.526	2.136
Inner Mongolia	1.056	1.590	1.536	2.107	2.963	3.636	4.111	5.027	5.641	5.987	5.906	5.687	4.353	7.194	4.417	5.312	5.398
Liaoning	0.959	0.863	0.990	1.267	1.928	2.070	3.612	2.732	3.531	4.385	4.690	4.620	4.142	6.307	3.569	3.106	3.632
Jilin	0.963	1.299	1.197	1.303	2.364	2.813	3.378	3.653	3.709	4.434	4.862	3.804	4.302	4.381	3.427	3.945	3.771
Heilongjiang	0.910	0.695	1.048	0.983	1.338	1.678	2.287	3.097	3.045	3.792	4.287	4.014	6.131	6.259	4.787	5.887	5.118
Shanghai	2.294	2.732	3.202	3.714	4.370	2.890	4.193	6.217	5.971	7.293	7.013	7.275	8.645	3.825	10.062	11.022	11.358
Jiangsu	1.431	1.912	2.272	2.568	2.822	3.234	3.539	4.116	4.685	5.816	6.057	6.241	6.783	7.468	7.834	9.561	9.923
Zhejiang	1.612	2.298	2.436	2.491	3.179	3.135	3.422	3.546	4.239	5.113	5.110	5.292	5.815	6.128	6.652	7.536	7.337
Anhui	0.780	0.709	1.112	1.111	1.415	1.720	1.883	1.889	2.171	2.870	3.174	3.227	3.650	4.170	4.273	5.146	4.867
Fujian	1.281	1.522	1.590	1.500	1.929	2.578	2.930	3.286	3.654	3.390	3.986	5.237	4.971	5.191	6.058	7.531	8.371
Jiangxi	0.731	0.861	1.033	0.916	1.238	1.451	1.638	2.149	2.067	3.047	2.910	3.107	3.509	3.257	3.202	3.872	3.625
Shandong	1.283	1.447	1.704	2.571	2.939	3.074	3.290	3.631	3.575	4.744	4.690	4.538	4.849	5.059	5.066	6.244	5.156
Henan	0.743	0.851	0.944	1.098	1.783	2.078	2.179	2.737	2.862	3.226	3.674	3.767	3.939	4.231	4.294	4.798	5.055
Hubei	0.708	0.772	0.976	1.196	1.543	1.809	1.884	2.415	2.636	3.448	3.676	4.033	4.726	5.334	5.412	6.341	6.372
Hunan	0.774	0.835	1.042	1.151	1.494	1.933	2.152	2.568	2.667	3.542	3.822	3.861	4.399	4.897	4.936	5.727	6.153
Guangdong	1.425	1.177	1.379	1.709	2.394	2.748	2.849	3.072	3.225	4.191	4.654	4.841	5.248	5.872	5.846	7.197	6.904
Guangxi	0.434	0.530	0.579	0.479	0.971	1.134	1.134	2.067	2.394	3.286	4.121	3.083	3.310	3.736	3.744	3.016	2.250
Hainan	0.510	0.588	0.631	0.517	0.981	0.673	1.224	1.408	1.295	1.866	2.555	2.690	2.555	3.141	3.597	3.551	4.113
Chongqing	0.981	1.364	1.237	1.371	1.569	2.160	2.673	2.409	2.720	3.359	3.577	3.801	4.697	5.296	5.420	6.253	6.243
Sichuan	0.817	1.009	1.101	1.299	1.543	2.018	0.123	2.136	2.227	2.991	3.202	3.152	3.576	3.970	4.004	4.716	3.095
Guizhou	0.589	0.513	0.564	0.884	0.819	1.358	0.988	1.693	1.708	2.025	2.348	2.591	3.144	3.686	3.754	4.753	5.035
Yunnan	0.676	0.782	0.784	0.857	1.115	1.289	1.037	1.477	1.676	2.359	2.894	3.341	3.690	4.618	4.039	5.139	5.194
Tibet	4.513	5.687	3.377	2.743	3.291	4.026	3.590	4.362	4.831	4.520	3.391	5.022	6.022	3.808	4.222	6.275	8.547
Shaanxi	0.712	0.819	0.910	0.990	1.447	2.123	2.560	2.765	3.111	3.730	4.069	4.423	4.612	4.591	4.570	5.518	6.043
Gansu	0.570	0.607	0.601	1.008	1.472	1.436	1.298	1.420	1.458	2.051	2.177	2.047	2.849	3.363	3.286	3.121	2.785
Qinghai	1.573	1.894	1.434	2.445	3.611	2.347	3.392	3.240	2.930	4.795	6.004	6.334	7.613	8.108	7.833	8.471	8.320
Ningxia	0.848	0.762	0.948	0.973	1.306	1.498	2.236	2.319	3.260	2.762	3.907	3.834	5.562	6.821	6.221	6.507	5.952
Xinjiang	0.896	1.175	1.043	0.698	1.297	1.377	1.193	1.232	1.492	2.244	2.766	3.053	4.226	4.057	3.196	5.204	5.893
China	0.973	1.124	1.252	1.507	1.955	2.236	2.363	2.875	3.070	3.842	4.093	4.136	4.573	4.944	4.892	5.739	5.577

A.4. WD_p by Province, 1985–2018

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	0.834	0.830	0.855	0.855	0.871	0.882	0.906	0.915	0.893	0.907	0.860	0.870	0.881	0.860	0.879	0.886	0.891
Tianjin	0.843	0.849	0.882	0.876	0.889	0.894	0.888	0.888	0.895	0.883	0.859	0.854	0.857	0.856	0.871	0.862	0.877
Hebei	0.905	0.911	0.910	0.906	0.909	0.913	0.911	0.909	0.904	0.910	0.901	0.900	0.900	0.901	0.905	0.909	0.910
Shanxi	0.892	0.903	0.914	0.908	0.914	0.916	0.915	0.913	0.904	0.911	0.907	0.903	0.891	0.886	0.896	0.900	0.904
Inner Mongolia	0.987	0.992	0.992	0.988	0.990	0.992	0.990	0.983	0.974	0.980	0.971	0.976	0.972	0.970	0.968	0.965	0.959
Liaoning	0.870	0.870	0.890	0.886	0.893	0.901	0.901	0.901	0.885	0.886	0.882	0.885	0.880	0.886	0.894	0.893	0.893
Jilin	0.879	0.888	0.902	0.902	0.906	0.903	0.906	0.906	0.890	0.894	0.891	0.891	0.900	0.889	0.901	0.910	0.906
Heilongjiang	0.889	0.896	0.907	0.909	0.913	0.908	0.913	0.910	0.891	0.881	0.872	0.867	0.889	0.893	0.892	0.894	0.900
Shanghai	0.837	0.843	0.870	0.862	0.866	0.871	0.886	0.886	0.863	0.858	0.825	0.833	0.824	0.837	0.848	0.840	0.865
Jiangsu	0.901	0.901	0.901	0.897	0.905	0.918	0.909	0.904	0.897	0.903	0.895	0.892	0.894	0.896	0.902	0.905	0.903
Zhejiang	0.899	0.900	0.901	0.900	0.904	0.913	0.905	0.902	0.895	0.891	0.878	0.877	0.885	0.889	0.897	0.904	0.902
Anhui	0.915	0.916	0.913	0.915	0.916	0.918	0.920	0.919	0.914	0.904	0.905	0.905	0.903	0.904	0.904	0.906	0.910
Fujian	0.909	0.912	0.913	0.911	0.911	0.916	0.916	0.913	0.893	0.891	0.879	0.884	0.884	0.884	0.891	0.898	0.901
Jiangxi	0.914	0.918	0.917	0.920	0.918	0.917	0.919	0.916	0.910	0.914	0.910	0.907	0.904	0.901	0.912	0.907	0.911
Shandong	0.895	0.900	0.906	0.908	0.909	0.912	0.907	0.905	0.903	0.905	0.904	0.912	0.890	0.890	0.892	0.896	0.895
Henan	0.921	0.922	0.921	0.920	0.921	0.922	0.921	0.921	0.918	0.918	0.911	0.910	0.911	0.912	0.916	0.915	0.913
Hubei	0.902	0.901	0.904	0.905	0.908	0.915	0.913	0.914	0.907	0.904	0.897	0.890	0.888	0.893	0.901	0.900	0.899
Hunan	0.916	0.918	0.918	0.918	0.921	0.918	0.917	0.918	0.915	0.915	0.913	0.904	0.904	0.908	0.908	0.907	0.912
Guangdong	0.909	0.903	0.910	0.908	0.912	0.917	0.916	0.910	0.902	0.902	0.890	0.897	0.900	0.903	0.903	0.916	0.909
Guangxi	0.934	0.938	0.938	0.934	0.935	0.937	0.932	0.930	0.922	0.916	0.913	0.908	0.912	0.916	0.916	0.917	0.919
Hainan				0.925	0.929	0.919	0.925	0.899	0.894	0.888	0.890	0.900	0.914	0.890	0.904	0.913	0.911
Chongqing													0.917	0.913	0.915	0.918	0.915
Sichuan	0.923	0.926	0.922	0.919	0.922	0.922	0.923	0.922	0.920	0.919	0.914	0.922	0.910	0.912	0.917	0.914	0.918
Guizhou	0.928	0.929	0.927	0.928	0.931	0.931	0.930	0.929	0.927	0.926	0.922	0.919	0.918	0.920	0.920	0.922	0.920
Yunnan	0.967	0.961	0.961	0.960	0.960	0.953	0.947	0.943	0.937	0.941	0.939	0.936	0.934	0.929	0.928	0.931	0.935
Tibet	0.829	0.826	0.827	0.817	0.819	0.813	0.836	0.832	0.822	0.846	0.861	0.855	0.862	0.875	0.886	0.896	0.911
Shaanxi	0.923	0.927	0.925	0.923	0.925	0.927	0.928	0.926	0.920	0.919	0.917	0.918	0.913	0.912	0.916	0.914	0.915
Gansu	0.944	0.941	0.941	0.942	0.942	0.943	0.940	0.939	0.939	0.935	0.935	0.934	0.931	0.931	0.928	0.928	0.928
Qinghai	0.980	0.979	0.984	0.981	0.971	0.969	0.980	0.985	0.995	0.993	0.992	0.993	0.993	0.992	0.992	0.991	0.986
Ningxia	0.938	0.935	0.930	0.939	0.945	0.943	0.939	0.936	0.919	0.922	0.920	0.921	0.927	0.913	0.927	0.916	0.913
Xinjiang	0.979	0.981	0.980	0.974	0.973	0.972	0.970	0.961	0.947	0.942	0.938	0.944	0.952	0.923	0.944	0.928	0.946
China	0.923	0.924	0.924	0.922	0.926	0.929	0.927	0.924	0.915	0.914	0.906	0.907	0.904	0.904	0.909	0.911	0.912

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beijing	0.907	0.874	0.907	0.836	0.848	0.862	0.884	0.860	0.861	0.876	0.869	0.869	0.865	0.876	0.850	0.865	0.860
Tianjin	0.883	0.878	0.872	0.871	0.846	0.863	0.850	0.821	0.826	0.824	0.813	0.823	0.824	0.845	0.837	0.851	0.863
Hebei	0.910	0.917	0.919	0.918	0.918	0.917	0.916	0.916	0.915	0.914	0.913	0.890	0.891	0.899	0.891	0.900	0.905
Shanxi	0.904	0.894	0.871	0.892	0.900	0.891	0.888	0.882	0.884	0.883	0.881	0.884	0.888	0.900	0.904	0.914	0.917
Inner Mongolia	0.943	0.892	0.877	0.863	0.895	0.896	0.895	0.878	0.888	0.895	0.858	0.863	0.885	0.857	0.875	0.878	0.891
Liaoning	0.894	0.881	0.884	0.876	0.876	0.873	0.841	0.873	0.865	0.865	0.868	0.870	0.869	0.848	0.880	0.906	0.909
Jilin	0.908	0.909	0.900	0.884	0.876	0.852	0.832	0.840	0.837	0.876	0.878	0.879	0.880	0.879	0.889	0.896	0.907
Heilongjiang	0.901	0.875	0.916	0.919	0.913	0.912	0.914	0.907	0.913	0.913	0.914	0.917	0.904	0.900	0.914	0.913	0.916
Shanghai	0.882	0.866	0.861	0.851	0.844	0.889	0.833	0.851	0.861	0.877	0.872	0.883	0.877	0.899	0.867	0.872	0.875
Jiangsu	0.905	0.900	0.897	0.897	0.887	0.893	0.886	0.878	0.880	0.884	0.883	0.874	0.871	0.876	0.867	0.875	0.872
Zhejiang	0.897	0.891	0.895	0.889	0.884	0.905	0.892	0.882	0.880	0.884	0.881	0.877	0.875	0.879	0.875	0.887	0.891
Anhui	0.913	0.906	0.914	0.915	0.915	0.916	0.913	0.907	0.906	0.908	0.912	0.910	0.908	0.911	0.906	0.909	0.905
Fujian	0.904	0.907	0.904	0.893	0.892	0.888	0.883	0.892	0.898	0.907	0.887	0.874	0.888	0.894	0.871	0.873	0.880
Jiangxi	0.913	0.901	0.896	0.888	0.895	0.903	0.906	0.902	0.899	0.906	0.897	0.901	0.913	0.913	0.907	0.910	0.907
Shandong	0.898	0.892	0.888	0.911	0.907	0.909	0.907	0.890	0.889	0.903	0.896	0.877	0.873	0.879	0.867	0.872	0.879
Henan	0.913	0.911	0.903	0.895	0.904	0.901	0.892	0.893	0.886	0.888	0.884	0.873	0.877	0.885	0.879	0.890	0.895
Hubei	0.896	0.896	0.894	0.910	0.902	0.900	0.898	0.898	0.898	0.894	0.885	0.879	0.880	0.881	0.875	0.879	0.889
Hunan	0.914	0.916	0.919	0.908	0.905	0.911	0.903	0.896	0.889	0.897	0.896	0.889	0.890	0.893	0.888	0.892	0.904
Guangdong	0.910	0.904	0.903	0.889	0.889	0.891	0.890	0.883	0.881	0.878	0.871	0.878	0.875	0.885	0.872	0.880	0.883
Guangxi	0.920	0.923	0.923	0.902	0.906	0.901	0.898	0.874	0.850	0.855	0.839	0.879	0.878	0.891	0.884	0.914	0.918
Hainan	0.916	0.920	0.912	0.910	0.901	0.903	0.887	0.893	0.878	0.884	0.868	0.873	0.862	0.869	0.868	0.883	0.889
Chongqing	0.914	0.916	0.899	0.888	0.892	0.904	0.875	0.892	0.894	0.893	0.893	0.894	0.889	0.892	0.882	0.888	0.887
Sichuan	0.919	0.920	0.919	0.918	0.913	0.917	0.901	0.897	0.894	0.900	0.896	0.898	0.899	0.908	0.903	0.902	0.917
Guizhou	0.921	0.921	0.927	0.890	0.912	0.918	0.914	0.917	0.909	0.916	0.911	0.902	0.905	0.902	0.892	0.899	0.898
Yunnan	0.933	0.931	0.925	0.912	0.911	0.912	0.924	0.901	0.888	0.894	0.885	0.885	0.886	0.887	0.885	0.887	0.894
Tibet	0.949	0.979	0.942	0.952	0.948	0.916	0.933	0.913	0.925	0.899	0.929	0.917	0.925	0.916	0.922	0.924	0.905
Shaanxi	0.922	0.910	0.909	0.903	0.898	0.916	0.909	0.898	0.891	0.880	0.872	0.875	0.872	0.888	0.879	0.883	0.894
Gansu	0.927	0.926	0.932	0.905	0.927	0.926	0.924	0.916	0.912	0.909	0.902	0.903	0.906	0.914	0.902	0.917	0.909
Qinghai	0.982	0.982	0.944	0.934	0.910	0.937	0.925	0.937	0.930	0.926	0.908	0.874	0.867	0.867	0.859	0.870	0.876
Ningxia	0.914	0.906	0.904	0.892	0.900	0.897	0.886	0.895	0.861	0.883	0.886	0.877	0.856	0.854	0.851	0.878	0.890
Xinjiang	0.941	0.942	0.933	0.927	0.916	0.922	0.921	0.907	0.901	0.919	0.896	0.899	0.883	0.900	0.905	0.898	0.901
China	0.913	0.909	0.907	0.901	0.900	0.904	0.897	0.891	0.888	0.893	0.887	0.884	0.883	0.889	0.882	0.890	0.896

A.5. WD_N by Province, 1985–2018

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	0.811	0.821	0.847	0.850	0.869	0.879	0.882	0.868	0.871	0.883	0.884	0.884	0.869	0.893	0.915	0.950	0.952
Tianjin	0.825	0.836	0.836	0.863	0.866	0.870	0.873	0.866	0.879	0.888	0.856	0.876	0.891	0.914	0.937	0.939	0.945
Hebei	0.879	0.875	0.883	0.910	0.895	0.904	0.900	0.912	0.921	0.918	0.912	0.880	0.906	0.903	0.910	0.931	0.937
Shanxi	0.877	0.886	0.868	0.895	0.881	0.874	0.894	0.903	0.900	0.895	0.875	0.849	0.827	0.815	0.836	0.870	0.886
Inner Mongolia	0.899	0.910	0.904	0.896	0.908	0.901	0.907	0.888	0.921	0.928	0.919	0.880	0.892	0.881	0.914	0.926	0.941
Liaoning	0.784	0.799	0.812	0.821	0.833	0.830	0.837	0.838	0.846	0.841	0.828	0.843	0.839	0.851	0.865	0.885	0.894
Jilin	0.831	0.859	0.880	0.872	0.889	0.886	0.896	0.909	0.919	0.899	0.851	0.901	0.881	0.878	0.909	0.928	0.944
Heilongjiang	0.784	0.846	0.867	0.860	0.872	0.858	0.878	0.872	0.889	0.885	0.882	0.890	0.865	0.868	0.904	0.915	0.929
Shanghai	0.751	0.762	0.776	0.785	0.802	0.789	0.798	0.802	0.825	0.830	0.824	0.838	0.807	0.821	0.862	0.882	0.894
Jiangsu	0.835	0.827	0.844	0.846	0.875	0.926	0.858	0.875	0.898	0.896	0.923	0.899	0.903	0.909	0.925	0.936	0.940
Zhejiang	0.893	0.897	0.896	0.898	0.920	0.918	0.925	0.893	0.915	0.906	0.938	0.925	0.938	0.951	0.953	0.960	0.970
Anhui	0.857	0.880	0.889	0.885	0.907	0.907	0.862	0.921	0.939	0.928	0.931	0.916	0.922	0.934	0.942	0.958	0.972
Fujian	0.883	0.902	0.881	0.887	0.917	0.911	0.934	0.934	0.935	0.917	0.928	0.928	0.942	0.945	0.948	0.968	0.975
Jiangxi	0.842	0.847	0.856	0.852	0.861	0.860	0.875	0.864	0.875	0.885	0.863	0.876	0.875	0.852	0.924	0.939	0.960
Shandong	0.924	0.930	0.918	0.918	0.937	0.938	0.935	0.921	0.939	0.941	0.951	0.934	0.933	0.938	0.957	0.970	0.972
Henan	0.873	0.879	0.897	0.890	0.920	0.916	0.924	0.930	0.937	0.935	0.931	0.940	0.926	0.934	0.938	0.941	0.956
Hubei	0.822	0.836	0.842	0.835	0.872	0.921	0.866	0.879	0.900	0.894	0.885	0.886	0.896	0.883	0.917	0.940	0.952
Hunan	0.840	0.841	0.856	0.865	0.880	0.877	0.893	0.907	0.927	0.927	0.929	0.891	0.913	0.899	0.942	0.964	0.969
Guangdong	0.908	0.910	0.920	0.917	0.931	0.941	0.930	0.933	0.930	0.925	0.946	0.949	0.937	0.936	0.945	0.963	0.959
Guangxi	0.896	0.908	0.889	0.887	0.902	0.893	0.903	0.914	0.920	0.891	0.927	0.893	0.919	0.916	0.931	0.955	0.956
Hainan				0.924	0.948	0.949	0.942	0.937	0.962	0.965	0.960	0.952	0.915	0.936	0.951	0.936	0.969
Chongqing													0.971	0.974	0.944	0.955	0.969
Sichuan	0.845	0.860	0.867	0.870	0.900	0.902	0.922	0.910	0.921	0.928	0.932	0.918	0.938	0.944	0.960	0.961	0.969
Guizhou	0.906	0.920	0.910	0.916	0.935	0.944	0.950	0.947	0.964	0.971	0.956	0.968	0.922	0.929	0.951	0.966	0.975
Yunnan	0.931	0.930	0.941	0.948	0.950	0.954	0.964	0.964	0.974	0.978	0.958	0.971	0.971	0.982	0.989	0.992	0.992
Tibet	0.906	0.909	0.911	0.894	0.907	0.919	0.932	0.954	0.977	0.971	0.982	0.977	0.897	0.908	0.935	0.999	0.978
Shaanxi	0.910	0.942	0.933	0.935	0.944	0.932	0.947	0.943	0.951	0.947	0.944	0.945	0.952	0.946	0.961	0.970	0.978
Gansu	0.904	0.923	0.920	0.922	0.937	0.925	0.930	0.935	0.952	0.930	0.908	0.917	0.905	0.914	0.936	0.950	0.962
Qinghai	0.895	0.899	0.937	0.934	0.932	0.971	0.946	0.953	0.952	0.957	0.947	0.969	0.952	0.955	0.961	0.967	0.978
Ningxia	0.892	0.903	0.903	0.911	0.901	0.900	0.913	0.907	0.913	0.911	0.911	0.890	0.905	0.902	0.921	0.932	0.956
Xinjiang	0.953	0.958	0.966	0.967	0.964	0.952	0.953	0.953	0.956	0.947	0.945	0.935	0.923	0.918	0.936	0.944	0.946
China	0.861	0.873	0.878	0.881	0.899	0.906	0.900	0.903	0.916	0.913	0.914	0.909	0.910	0.913	0.932	0.947	0.955

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beijing	0.952	0.959	0.997	0.962	0.967	0.963	0.960	0.959	0.943	0.954	0.949	0.944	0.947	0.941	0.937	0.928	0.920
Tianjin	0.945	0.950	0.952	0.957	0.958	0.966	0.971	0.973	0.968	0.970	0.966	0.959	0.962	0.963	0.958	0.959	0.955
Hebei	0.948	0.950	0.949	0.963	0.962	0.966	0.971	0.975	0.974	0.972	0.969	0.970	0.969	0.970	0.969	0.970	0.967
Shanxi	0.897	0.906	0.913	0.936	0.931	0.933	0.942	0.953	0.965	0.963	0.966	0.964	0.958	0.961	0.964	0.970	0.984
Inner Mongolia	0.958	0.958	0.953	0.963	0.935	0.953	0.952	0.955	0.968	0.959	0.962	0.968	0.968	0.969	0.971	0.974	0.973
Liaoning	0.913	0.918	0.919	0.932	0.926	0.929	0.942	0.948	0.957	0.951	0.952	0.963	0.964	0.968	0.971	0.971	0.973
Jilin	0.957	0.968	0.966	0.968	0.971	0.971	0.973	0.972	0.961	0.971	0.973	0.970	0.967	0.968	0.962	0.963	0.960
Heilongjiang	0.947	0.948	0.949	0.961	0.957	0.955	0.963	0.966	0.966	0.959	0.962	0.966	0.972	0.973	0.971	0.972	0.969
Shanghai	0.908	0.919	0.924	0.942	0.940	0.971	0.955	0.961	0.967	0.967	0.966	0.967	0.969	0.987	0.964	0.965	0.959
Jiangsu	0.949	0.953	0.959	0.965	0.969	0.974	0.977	0.979	0.973	0.977	0.977	0.975	0.977	0.977	0.974	0.973	0.969
Zhejiang	0.967	0.974	0.968	0.972	0.979	0.979	0.977	0.980	0.972	0.978	0.977	0.974	0.967	0.961	0.952	0.951	0.944
Anhui	0.978	0.979	0.986	0.983	0.990	0.988	0.987	0.985	0.966	0.983	0.977	0.973	0.967	0.979	0.976	0.971	0.966
Fujian	0.976	0.980	0.976	0.973	0.976	0.984	0.986	0.987	0.983	0.984	0.982	0.973	0.971	0.970	0.967	0.963	0.956
Jiangxi	0.965	0.969	0.972	0.977	0.977	0.982	0.977	0.986	0.979	0.984	0.983	0.982	0.978	0.926	0.912	0.906	0.891
Shandong	0.974	0.979	0.977	0.978	0.981	0.983	0.986	0.985	0.979	0.982	0.981	0.976	0.977	0.974	0.976	0.977	0.975
Henan	0.970	0.977	0.978	0.978	0.983	0.981	0.981	0.982	0.973	0.980	0.979	0.974	0.970	0.967	0.960	0.956	0.947
Hubei	0.969	0.973	0.976	0.977	0.980	0.982	0.981	0.984	0.976	0.981	0.980	0.977	0.970	0.968	0.966	0.961	0.953
Hunan	0.969	0.972	0.976	0.983	0.986	0.989	0.988	0.991	0.983	0.989	0.988	0.987	0.983	0.982	0.976	0.978	0.968
Guangdong	0.972	0.975	0.981	0.987	0.987	0.990	0.991	0.992	0.984	0.989	0.988	0.981	0.982	0.980	0.975	0.973	0.965
Guangxi	0.969	0.968	0.974	0.977	0.979	0.979	0.977	0.992	0.986	0.992	0.993	0.989	0.983	0.977	0.966	0.964	0.978
Hainan	0.977	0.964	0.969	0.952	0.975	0.967	0.969	0.972	0.966	0.968	0.974	0.973	0.964	0.970	0.967	0.964	0.957
Chongqing	0.976	0.982	0.983	0.987	0.988	0.992	0.996	0.993	0.986	0.991	0.990	0.982	0.982	0.978	0.976	0.974	0.967
Sichuan	0.976	0.978	0.979	0.980	0.985	0.987	0.866	0.989	0.983	0.990	0.990	0.986	0.986	0.983	0.978	0.979	0.977
Guizhou	0.977	0.977	0.979	0.990	0.995	0.995	0.988	0.993	0.985	0.991	0.991	0.989	0.987	0.984	0.979	0.977	0.970
Yunnan	0.992	0.992	0.994	0.988	0.994	0.993	0.988	0.991	0.981	0.990	0.990	0.985	0.982	0.975	0.964	0.959	0.953
Tibet	0.962	0.945	0.981	0.939	0.931	0.912	0.924	0.938	0.889	0.937	0.908	0.944	0.904	0.940	0.876	0.870	0.845
Shaanxi	0.981	0.980	0.984	0.987	0.985	0.987	0.985	0.993	0.987	0.990	0.992	0.990	0.988	0.986	0.985	0.986	0.984
Gansu	0.974	0.970	0.970	0.985	0.980	0.986	0.954	0.987	0.982	0.988	0.988	0.982	0.988	0.986	0.983	0.982	0.987
Qinghai	0.980	0.984	0.978	0.980	0.981	0.980	0.981	0.983	0.956	0.981	0.982	0.985	0.985	0.986	0.984	0.985	0.981
Ningxia	0.954	0.918	0.925	0.941	0.949	0.942	0.952	0.956	0.963	0.955	0.955	0.955	0.953	0.960	0.962	0.965	0.968
Xinjiang	0.955	0.946	0.945	0.951	0.945	0.948	0.950	0.952	0.956	0.953	0.955	0.958	0.948	0.959	0.965	0.969	0.970
China	0.964	0.968	0.971	0.976	0.977	0.980	0.975	0.984	0.979	0.982	0.982	0.979	0.978	0.980	0.973	0.972	0.969

A.6. SGPI per capita by Province, 1985–2018 (2018 Thousand US Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beijing	-0.045	0.059	0.300	0.149	-0.106	-0.147	-0.299	-0.342	-0.129	-0.219	0.572	0.489	0.301	0.975	0.999	1.402	1.735
Tianjin	0.277	0.239	0.233	0.252	0.091	0.050	0.144	0.227	0.208	0.247	0.049	0.473	0.513	0.872	0.915	1.097	1.052
Hebei	0.197	0.158	0.177	0.179	0.114	0.127	0.116	0.197	0.219	0.258	0.340	0.269	0.495	0.492	0.628	0.621	0.697
Shanxi	0.177	0.128	0.093	-0.023	-0.046	-0.052	0.001	0.058	0.073	0.003	-0.067	-0.203	-0.321	-0.300	-0.312	-0.079	-0.089
Inner Mongolia	0.526	0.480	0.439	0.449	0.375	0.377	0.372	0.352	0.421	0.457	0.500	0.302	0.357	0.314	0.471	0.499	0.611
Liaoning	-0.156	-0.142	-0.020	-0.036	-0.149	-0.207	-0.162	-0.116	0.020	-0.117	-0.401	-0.163	-0.163	-0.005	0.017	0.015	0.184
Jilin	0.122	0.129	0.214	0.112	0.025	0.069	0.048	0.112	0.216	0.184	-0.144	0.320	0.179	0.346	0.419	0.412	0.619
Heilongjiang	-0.479	0.045	0.097	0.023	-0.057	-0.122	-0.065	0.007	0.114	0.103	0.026	0.158	0.047	0.126	0.431	0.493	0.549
Shanghai	-0.756	-0.613	-0.286	-0.212	-0.287	-0.570	-0.426	-0.248	0.233	0.431	0.473	0.434	0.496	0.807	1.270	2.197	1.404
Jiangsu	0.190	0.134	0.214	0.192	0.103	-0.064	-0.077	0.153	0.325	0.377	0.653	0.630	0.693	0.756	0.863	0.873	0.925
Zhejiang	0.221	0.222	0.277	0.262	0.182	0.130	0.221	0.169	0.474	0.486	0.764	0.763	0.835	0.904	0.871	0.828	1.036
Anhui	0.181	0.208	0.212	0.162	0.134	0.106	-0.139	0.120	0.212	0.220	0.286	0.260	0.341	0.376	0.391	0.469	0.559
Fujian	0.158	0.196	0.184	0.203	0.175	0.135	0.251	0.375	0.489	0.567	0.692	0.782	0.875	0.956	0.969	1.003	1.037
Jiangxi	0.083	0.075	0.076	0.027	0.009	0.010	0.050	0.058	0.057	0.097	0.049	0.221	0.219	0.061	0.379	0.466	0.563
Shandong	0.256	0.275	0.312	0.270	0.204	0.196	0.228	0.257	0.310	0.420	0.340	0.213	0.465	0.553	0.705	0.775	0.880
Henan	0.160	0.185	0.171	0.120	0.120	0.093	0.122	0.148	0.172	0.237	0.260	0.349	0.321	0.372	0.375	0.323	0.558
Hubei	0.043	0.027	0.020	-0.112	-0.059	-0.172	-0.195	-0.085	-0.015	0.002	0.059	0.151	0.234	0.154	0.336	0.407	0.492
Hunan	0.036	0.036	0.069	0.035	-0.032	0.011	0.060	0.111	0.186	0.163	0.185	0.044	0.245	0.163	0.419	0.530	0.554
Guangdong	0.219	0.204	0.279	0.337	0.282	0.280	0.250	0.481	0.607	0.772	0.847	0.767	0.803	0.966	0.888	0.882	
Guangxi	0.084	0.117	0.077	0.039	0.019	0.009	0.044	0.095	0.152	-0.014	0.158	0.045	0.173	0.174	0.243	0.245	0.210
Hainan				0.293	0.294	0.341	0.281	0.494	0.543	0.660	0.607	0.443	0.203	0.489	0.442	0.236	0.408
Chongqing													0.531	0.575	0.357	0.492	0.598
Sichuan	0.096	0.114	0.111	0.095	0.101	0.111	0.141	0.113	0.112	0.169	0.199	0.165	0.287	0.386	0.483	0.461	0.536
Guizhou	0.173	0.183	0.154	0.114	0.086	0.083	0.102	0.113	0.164	0.166	0.180	0.268	0.101	0.145	0.273	0.343	0.353
Yunnan	0.217	0.233	0.256	0.266	0.221	0.254	0.315	0.339	0.372	0.365	0.301	0.389	0.413	0.508	0.599	0.539	0.512
Tibet	3.388	3.089	3.623	3.468	3.452	3.555	3.507	3.420	3.143	3.232	3.205	2.925	2.861	2.961	3.041	3.417	3.666
Shaanxi	0.212	0.251	0.235	0.227	0.172	0.164	0.170	0.165	0.205	0.210	0.194	0.211	0.269	0.328	0.380	0.479	0.595
Gansu	0.189	0.243	0.206	0.179	0.158	0.101	0.123	0.138	0.052	0.096	0.037	0.132	0.082	0.143	0.280	0.299	0.324
Qinghai	1.035	0.943	1.034	0.990	0.787	0.677	0.860	0.897	0.992	0.943	0.915	1.085	1.013	1.054	1.071	1.154	1.363
Ningxia	0.236	0.284	0.197	0.169	0.052	0.049	0.071	0.047	0.030	0.015	-0.014	0.013	0.054	0.228	0.230	0.415	0.571
Xinjiang	0.524	0.529	0.478	0.476	0.409	0.418	0.385	0.438	0.395	0.424	0.357	0.247	0.159	0.468	0.344	0.659	0.539
China	1.548	0.174	0.193	0.161	0.115	0.092	0.099	0.168	0.243	0.262	0.300	0.315	0.373	0.429	0.529	0.588	0.653

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beijing	1.559	1.662	-0.194	2.334	2.583	3.505	2.139	2.833	2.914	3.782	4.137	4.480	4.857	4.872	5.588	6.571	7.131
Tianjin	1.272	1.362	1.472	1.819	1.864	1.784	3.068	4.208	3.953	5.467	5.158	5.574	6.345	6.226	5.867	6.511	5.289
Hebei	0.698	1.123	1.374	1.448	1.928	2.093	2.574	2.870	2.654	3.307	3.103	2.244	2.609	2.715	2.535	2.958	2.705
Shanxi	-0.004	-0.081	0.055	0.381	0.651	0.721	0.875	1.546	1.467	1.886	1.601	1.857	2.068	2.463	1.617	1.490	1.159
Inner Mongolia	0.901	1.255	1.128	1.564	2.336	2.967	3.352	3.984	4.579	4.896	4.433	4.278	3.273	5.451	3.188	3.478	3.644
Liaoning	0.549	0.417	0.511	0.688	1.258	1.330	2.499	1.891	2.495	3.215	3.458	3.420	2.967	4.636	2.549	1.878	2.343
Jilin	0.729	1.039	0.905	0.933	1.851	2.100	2.474	2.690	2.599	3.549	3.915	2.952	3.386	3.428	2.615	2.866	2.759
Heilongjiang	0.646	0.391	0.784	0.730	1.034	1.318	1.888	2.578	2.531	3.195	3.632	3.382	5.227	5.289	4.037	4.779	4.075
Shanghai	1.442	1.752	2.108	2.489	2.988	2.057	2.759	4.614	4.434	5.810	5.492	5.791	6.927	2.538	7.829	8.415	8.669
Jiangsu	1.099	1.500	1.803	2.024	2.213	2.600	2.818	3.251	3.686	4.723	4.903	4.935	5.364	5.978	6.127	7.202	7.418
Zhejiang	1.223	1.809	1.905	1.875	2.498	2.545	2.708	2.730	3.240	4.069	4.009	4.083	4.517	4.741	5.073	5.615	5.417
Anhui	0.635	0.546	0.932	0.900	1.186	1.449	1.576	1.542	1.708	2.378	2.637	2.647	3.007	3.548	3.571	4.053	3.734
Fujian	1.017	1.238	1.264	1.101	1.478	2.051	2.322	2.658	2.960	2.768	3.153	4.114	3.969	4.179	4.676	5.592	6.347
Jiangxi	0.579	0.675	0.815	0.673	0.975	1.182	1.333	1.790	1.633	2.577	2.393	2.570	2.989	2.447	2.231	2.541	2.156
Shandong	1.017	1.145	1.342	2.167	2.480	2.590	2.765	2.942	2.812	3.973	3.839	3.527	3.747	3.927	3.778	4.359	3.413
Henan	0.593	0.681	0.743	0.834	1.480	1.712	1.759	2.241	2.251	2.606	2.957	2.944	3.091	3.370	3.332	3.536	3.734
Hubei	0.496	0.545	0.721	0.927	1.222	1.437	1.474	1.942	2.071	2.795	2.927	3.170	3.762	4.272	4.221	4.731	4.782
Hunan	0.636	0.659	0.848	0.898	1.206	1.616	1.769	2.110	2.117	2.958	3.179	3.146	3.620	4.064	4.016	4.332	4.774
Guangdong	1.104	0.841	1.023	1.238	1.855	2.169	2.242	2.385	2.433	3.293	3.605	3.784	4.101	4.714	4.505	5.242	4.947
Guangxi	0.302	0.384	0.426	0.261	0.726	0.832	0.784	1.561	1.660	2.501	3.090	2.409	2.589	3.011	2.931	2.061	1.360
Hainan	0.375	0.419	0.445	0.259	0.717	0.390	0.824	0.994	0.738	1.279	1.818	1.937	1.664	2.222	2.538	2.249	2.714
Chongqing	0.786	1.141	0.974	1.022	1.204	1.778	2.090	1.925	2.161	2.743	2.920	3.092	3.845	4.373	4.336	4.701	4.635
Sichuan	0.671	0.844	0.921	1.075	1.294	1.731	-0.617	1.745	1.754	2.491	2.646	2.558	2.962	3.351	3.316	3.590	2.167
Guizhou	0.477	0.400	0.450	0.666	0.649	1.145	0.774	1.426	1.366	1.684	1.946	2.095	2.590	3.030	2.970	3.388	3.572
Yunnan	0.573	0.665	0.649	0.668	0.908	1.060	0.842	1.168	1.237	1.885	2.294	2.658	2.948	3.747	3.143	3.635	3.672
Tibet	4.226	5.519	3.119	2.513	3.044	3.538	3.219	3.827	4.209	3.876	2.961	4.390	5.327	3.095	3.330	4.940	6.684
Shaanxi	0.574	0.643	0.721	0.756	1.147	1.794	2.137	2.274	2.483	2.987	3.207	3.501	3.633	3.703	3.588	3.963	4.491
Gansu	0.449	0.467	0.464	0.781	1.245	1.212	0.973	1.144	1.118	1.669	1.732	1.547	2.330	2.819	2.643	2.088	1.692
Qinghai	1.508	1.825	1.258	2.154	3.128	2.063	2.968	2.876	2.381	4.223	5.176	5.146	6.186	6.574	6.178	6.366	6.253
Ningxia	0.645	0.449	0.609	0.560	0.907	1.004	1.605	1.693	2.286	1.942	2.926	2.759	4.068	5.103	4.501	4.569	4.170
Xinjiang	0.718	0.961	0.805	0.453	0.966	1.038	0.852	0.833	0.998	1.746	2.056	2.293	3.169	3.158	2.411	3.783	4.410
China	0.757	0.879	0.979	1.164	1.566	1.817	1.863	2.305	2.399	3.131	3.290	3.270	3.641	3.978	3.825	4.236	4.089

A.7. Provincial WD_p , WD_N , GDP per capita, GPI per capita, SGPI per capita and GPI Decomposed to Accounts, 1985–2018

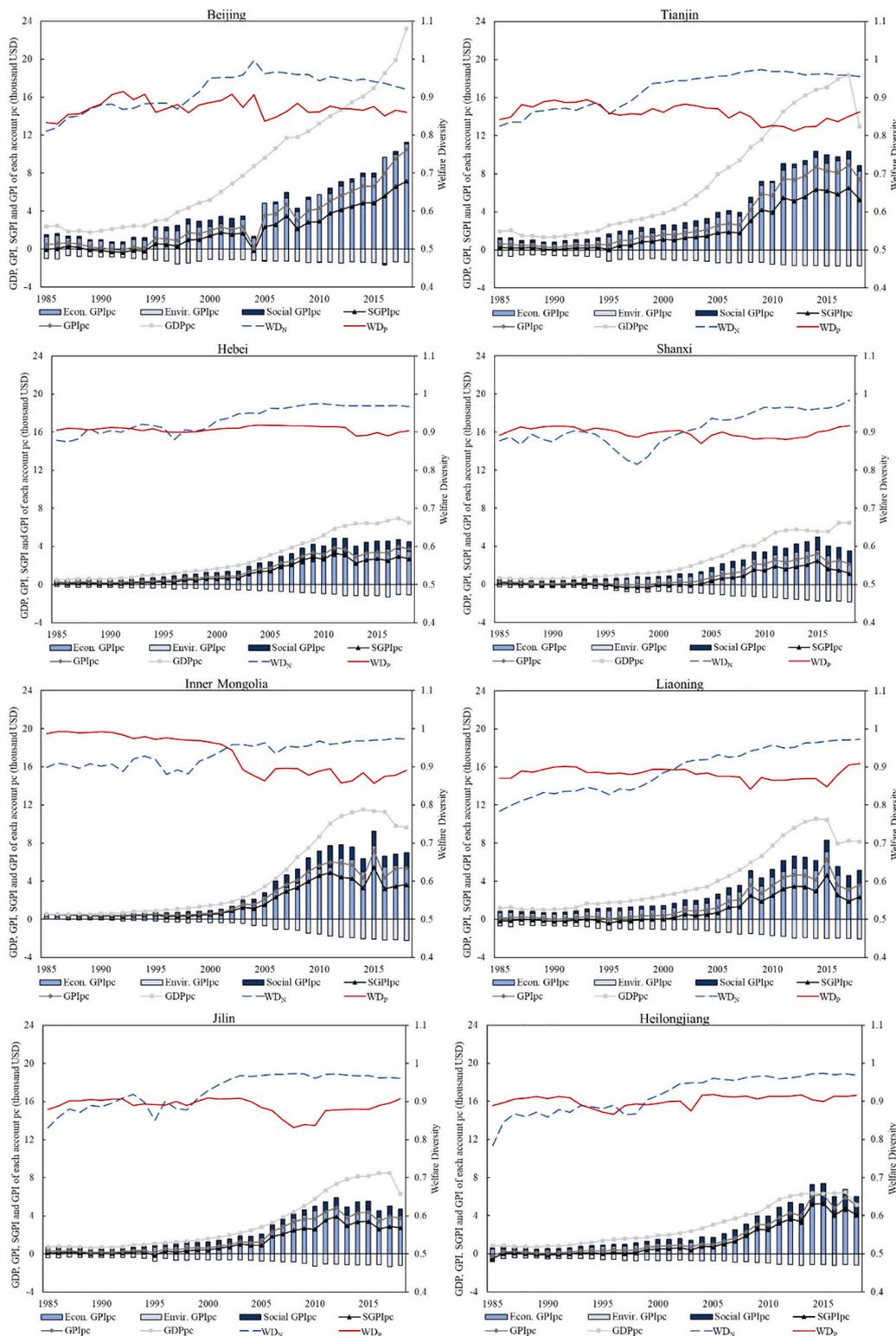


Fig. A1. Provincial WD_p , WD_N , GDP per capita, GPI per capita, SGPI per capita and GPI decomposed to dimensions, 1985–2018. Notes: GDP, GPI, SGPI, and GPI by components are shown in the primary y-axis, and WD_p and WD_N are shown in the secondary y-axis. Since Chongqing Municipality was established in 1997, the beginning year of the statistical data and all the estimations of Chongqing is 1997. Hainan Province is under the same circumstance, and it was separated from Guangdong Province and set up as a province in 1988. Hence, all the results of Hainan start at 1988.

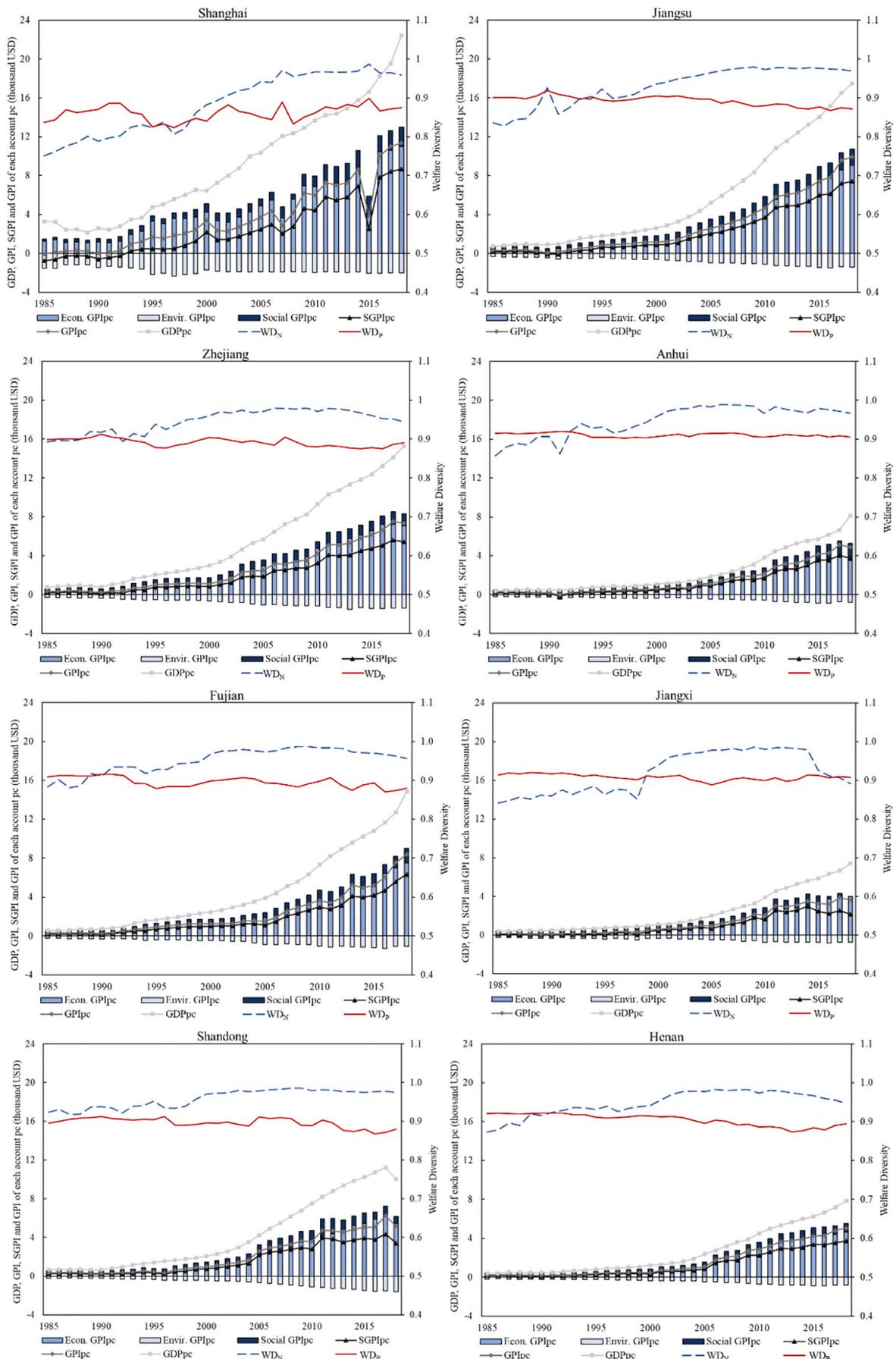


Fig. A1. (continued).

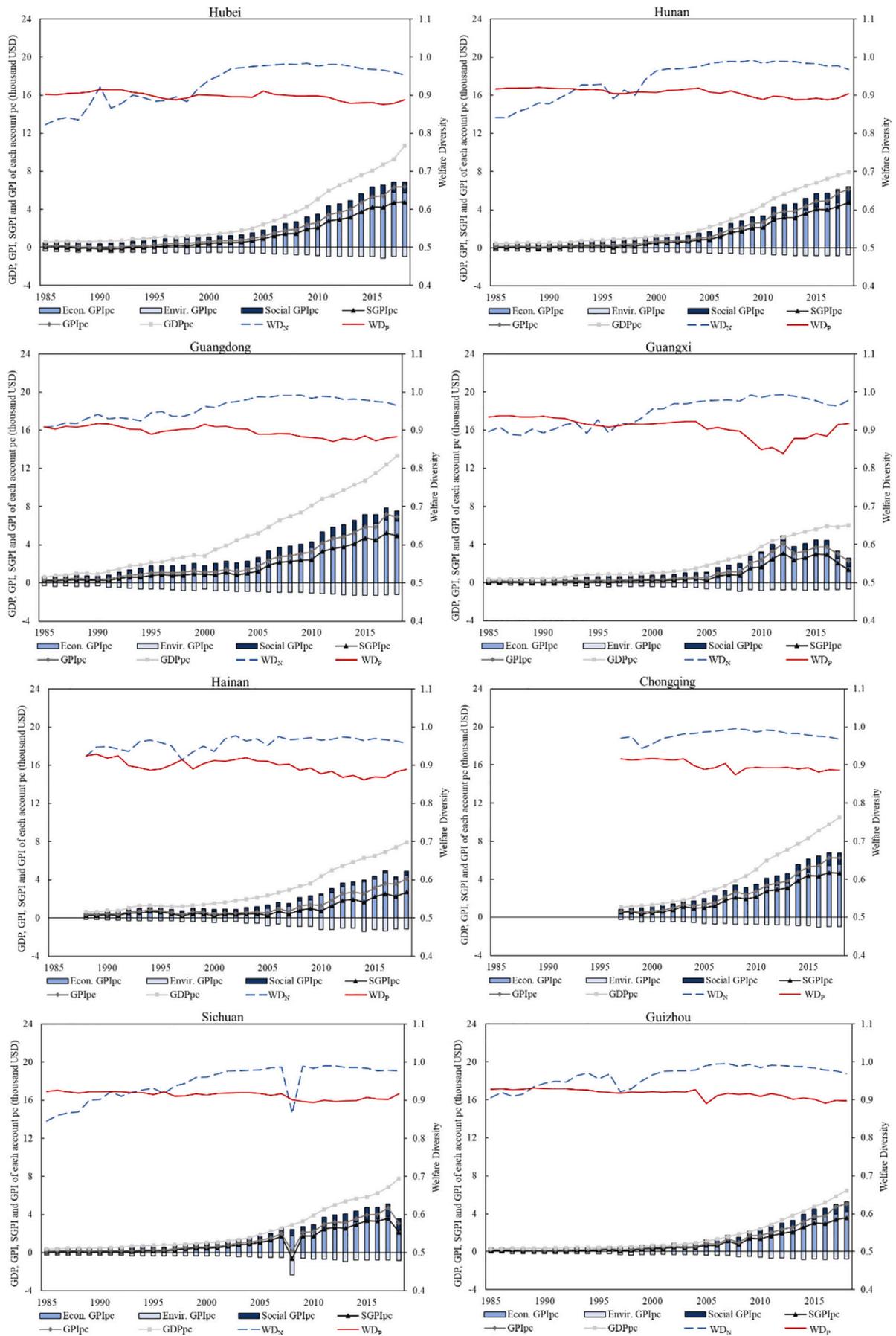


Fig. A1. (continued).

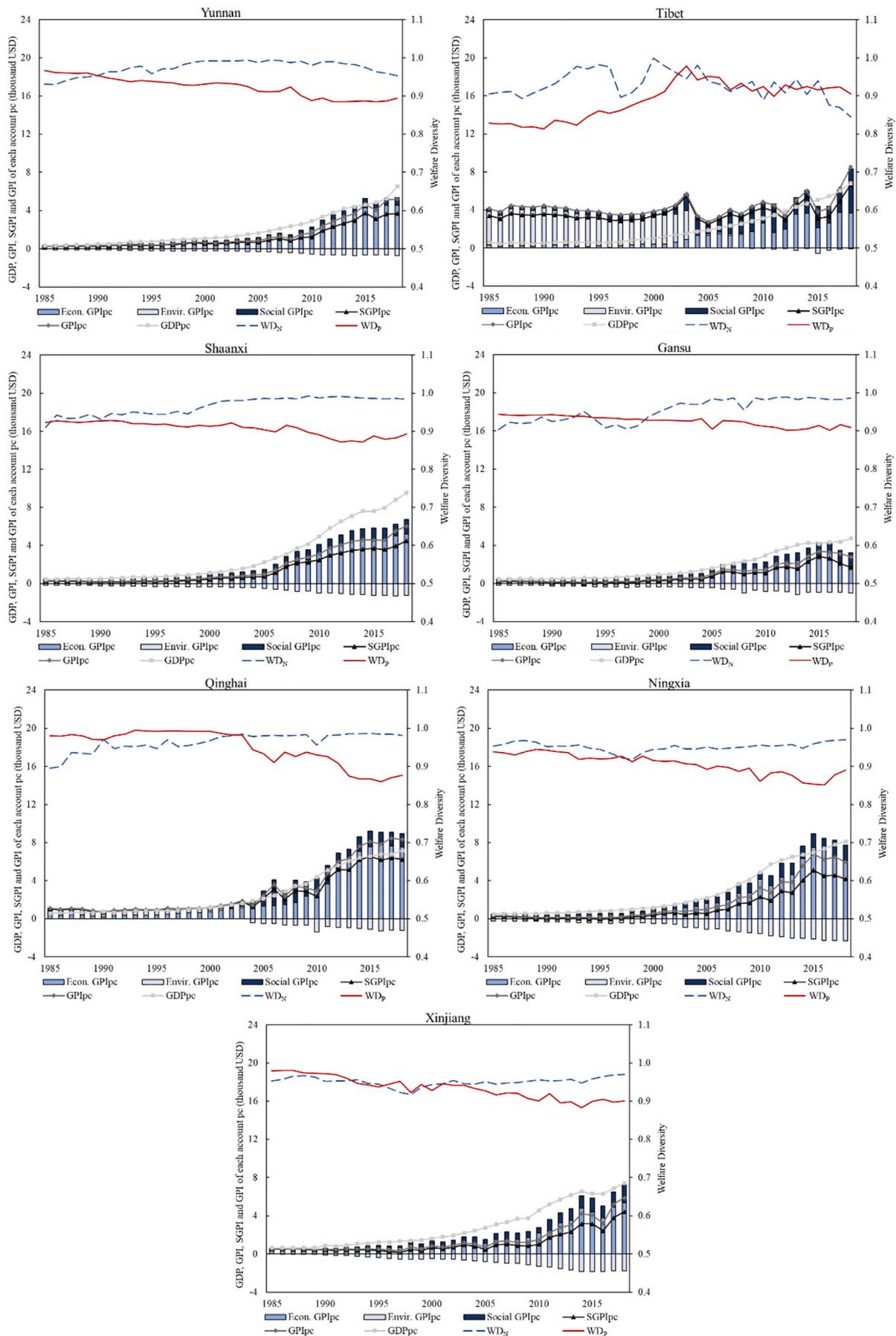


Fig. A1. (continued).

A.8. Explanations for significant fluctuations of SWI

Prefecture	Year	Dimension	Main reason
Beijing	1991	Economy	The 11th Asian Games, hosted by Beijing in 1990, marked the first instance of a Chinese city hosting an international athletic event. In the subsequent year of 1991, personal consumption expenditures and net capital growth experienced a relative decline.
	2003–2005	Economy and Society	In 2003, the SARS pandemic ravaged China, with Beijing emerging as the most severely affected region. This health crisis led to economic stagnation and significant societal distress within Beijing. It was not until the end of 2004, following the containment of SARS, that the situation began to improve. As a result, Beijing experienced a steep decline in its per capita SDI in 2004, which was followed by a subsequent increase in 2005.
Sichuan	2008	All three	The 2008 Wenchuan earthquake.
Shanxi	1996–1997	Environment	Shanxi province suffered from severe floods in 1996 and 1997, leading to a negative impact on its SDI.
	1999–2000	Economy	A rise in employment toward the end of the 20th century caused low net capital growth.
Liaoning	2004	Economy	Economic structure adjustment in 2004.
	1996	Environment	A flood disaster occurred on the Songhua River.
Jilin	1996	Environment	A flood disaster occurred on the Songhua River.
Heilongjiang	1986	Environment	Heilongjiang province rebounded from the flood disaster of 1985 in the subsequent year, 1986.
Shanghai	1986–1987	All three	Following China's economic reform in 1984, Shanghai embarked on a trajectory of accelerated growth that spanned several years.
	1991–1993	Economy	The State Council endorsed the hastened development of the Pudong region in Shanghai, furthering the implementation of economic zones.
	2015–2016	Economy	In 2015, Shanghai experienced a substantial employment surge due to the enforcement of the city's population policy, leading to a negative net capital growth. However, it rebounded positively in 2016, attributed to increasing capital investment and stable employment.
Jiangsu	1991–1992	Economy	In 1991, Jiangsu province enacted several policies, including "certain provisions of Jiangsu province on encouraging investment by overseas Chinese and compatriots from Hong Kong, Macao, and Taiwan," aimed at stimulating fixed asset investment. Consequently, there was an uptick in fixed asset investment, resulting in positive net capital growth for that year.
Anhui	1991–1992	Environment	In 1991, Anhui province was afflicted by a flood disaster, but it managed to recuperate by the following year, 1992.
Hubei	1990	Economy	A rise in employment in 1990.
	1992–1993	Environment	Hubei recovered from flood disaster in 1992 and 1993.
Guangxi	1995	Environment	Low cost of natural disaster.
	2006	Society	Low cost of divorce.
Ningxia	1998	Economy	Employment decreased because of unhealthy state-owned economy and the inactive private economy.
Xinjiang	1998	Economy	Employment decreased because of unhealthy state-owned economy and the inactive private economy.

Notes: The records in this table have change rate of GPI per capita exceeds 100 % compared with the previous year.

A.9. Sensitivity analysis on component selection

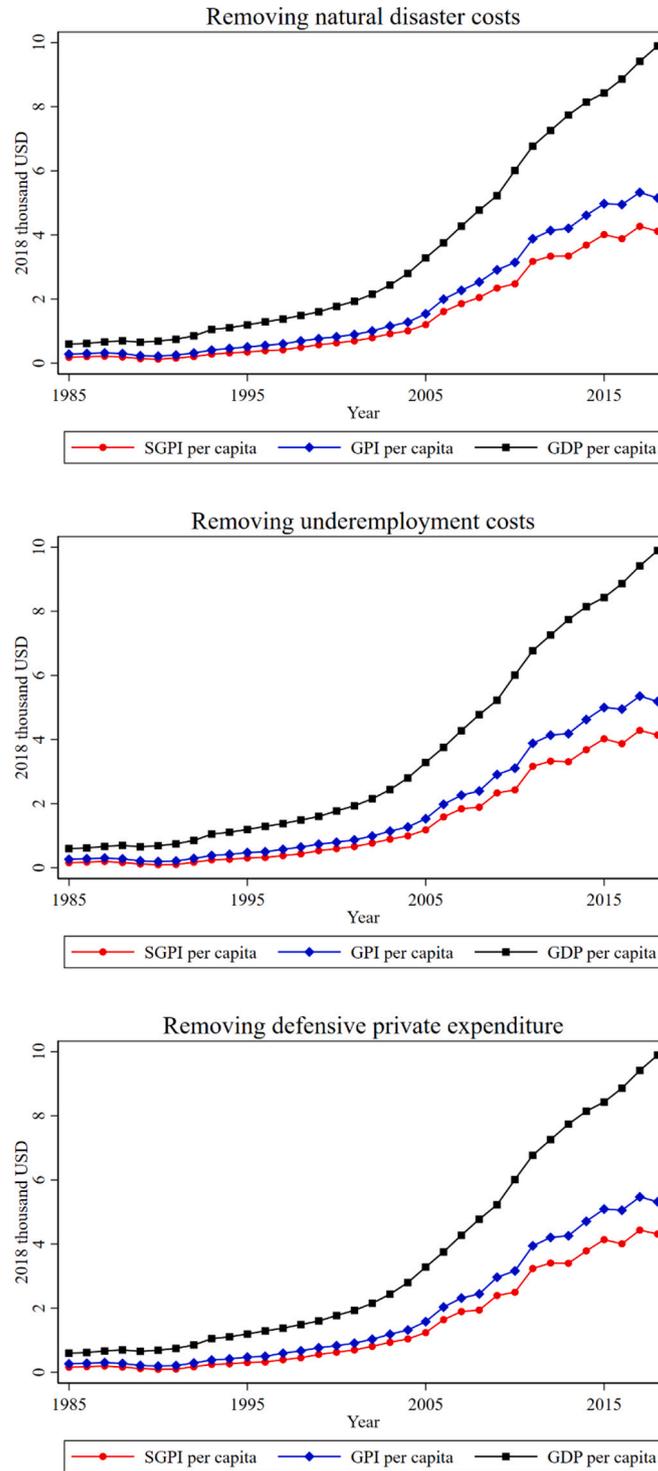


Fig. A2. Sensitivity analysis on component selection: national trend.

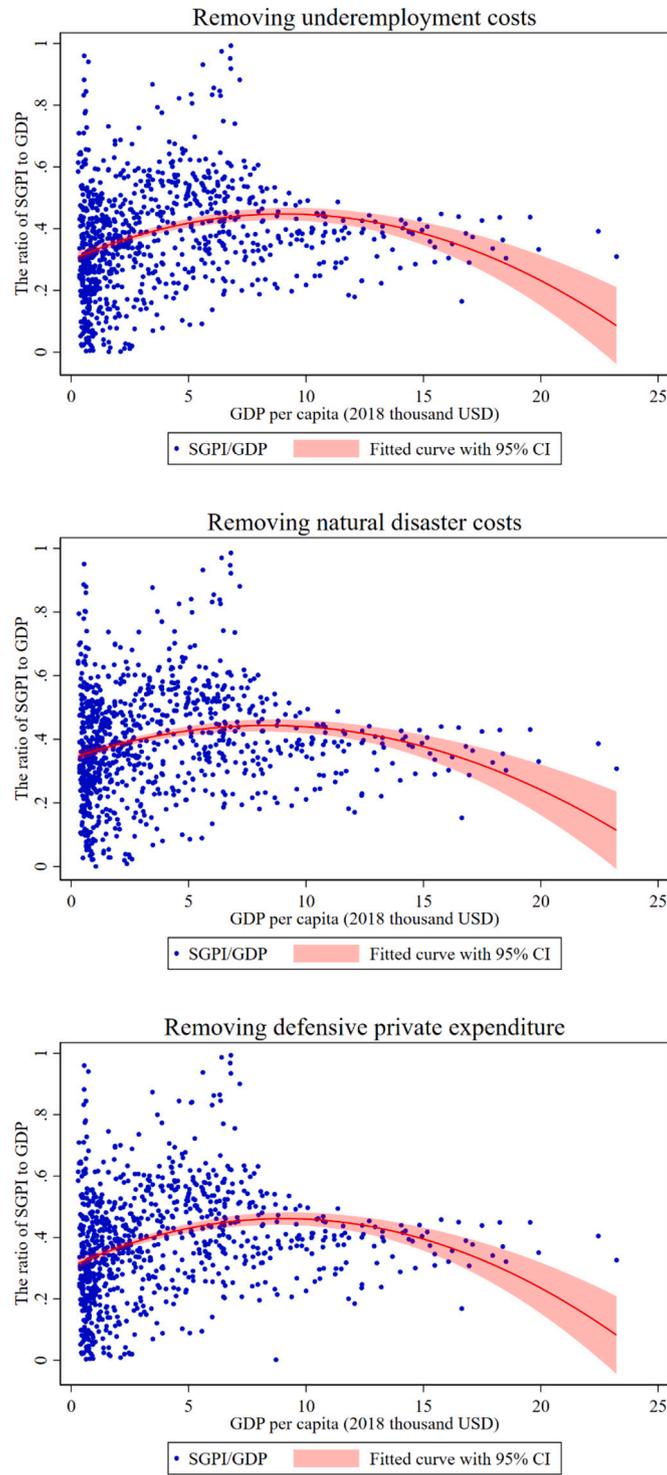


Fig. A3. Sensitivity analysis on component selection: Sustainable Kuznets Curve.

A.10. Sensitivity analysis on component estimation

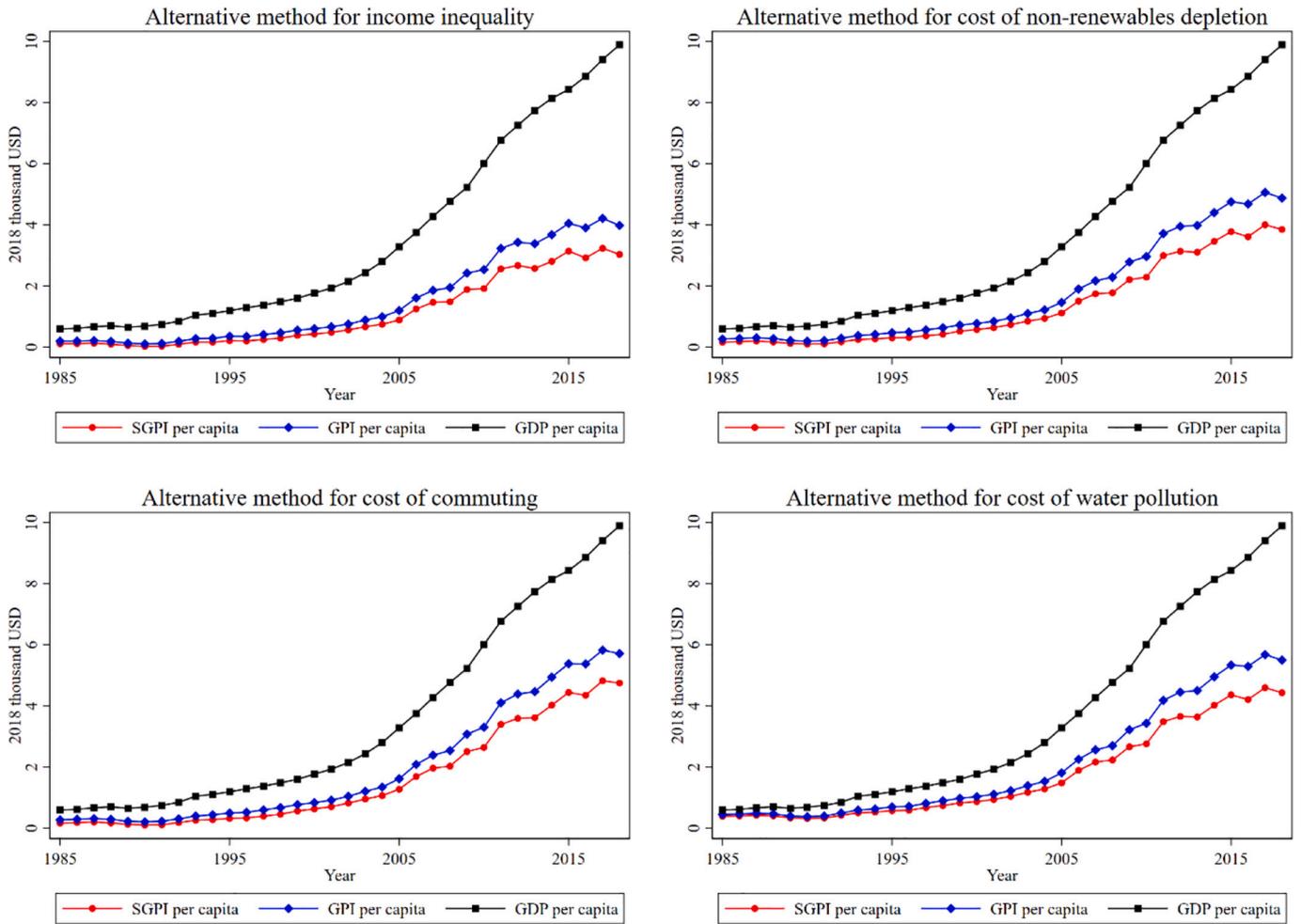


Fig. A4. Sensitivity analysis on component estimation: national trend.

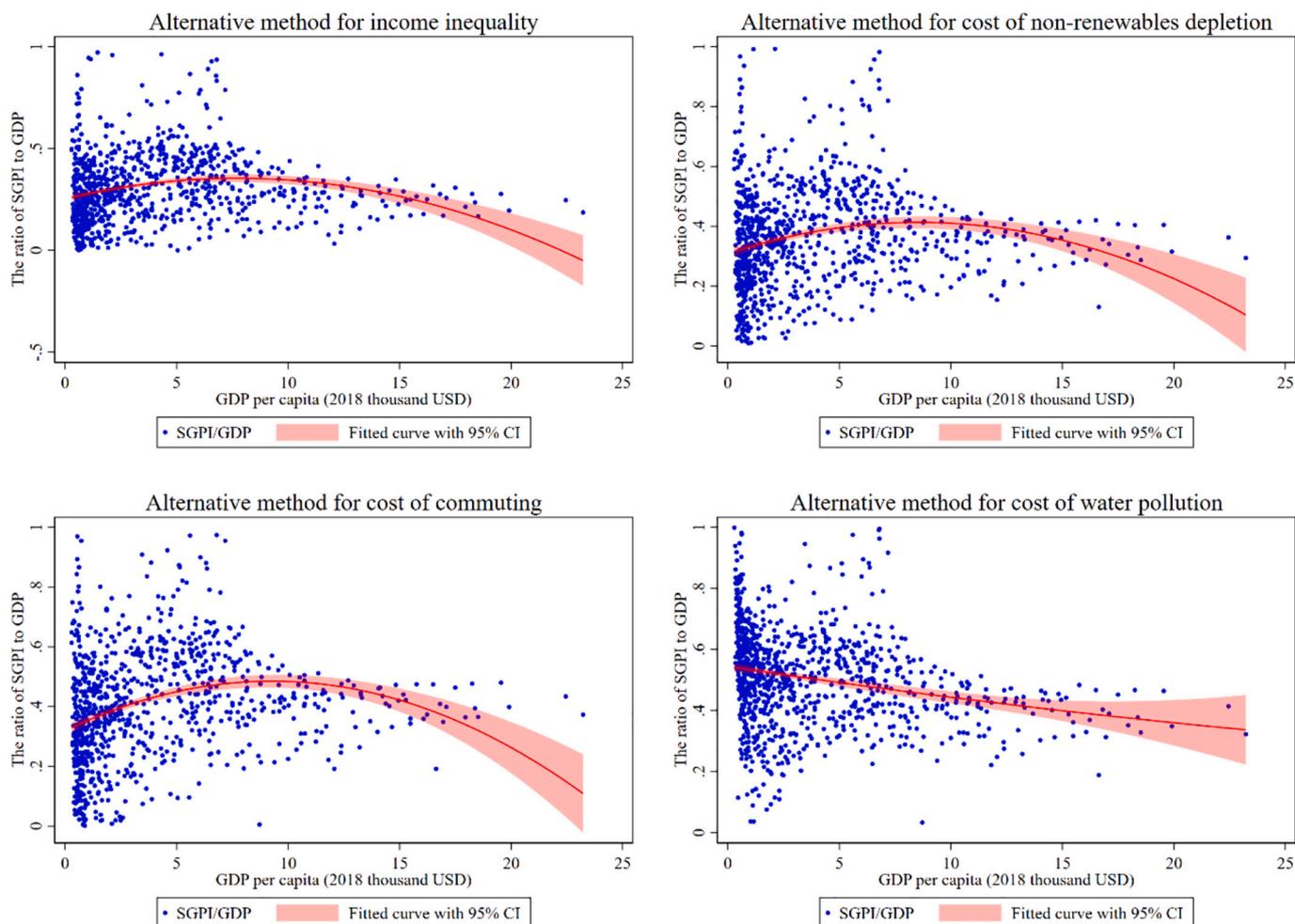


Fig. A5. Sensitivity analysis on component estimation: Sustainable Kuznets Curve.

Data availability

Data will be made available on request.

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