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Behavioral economics (BE): a neuroeconomic alternative to the paradigm of bounded rationality

Abstract

The ruling dogma on Bounded Rationality (BR) is much criticized, but no alternative is yet acceptable! Neuroeconomics is a new multidisciplinary field by Economics, Psychology and Neurology based on the Triune Brain Model (TBM).

TBM constitutes cognitive dialectics, where Ventromedial PFC generates *intuition*. The Dorsolateral PFC does *cognitive analysis*. Neuroeconomic trials identify general risk-willingness as cognitive parameter ruling economic behavior. Risk-willingness orders Tempers in a positivist *Behavioral Economics* (BE) that guides individual economic behavior towards practical competences, such as:

a) Sensitivity-training for collaboration by the Dohmen Scale on General Risk-willingness including, too, familiarity with "Pilot-in-the-plane" entrepreneurship.

b) Stress-management by meditative in-depth-relaxation. In the short-run the stress-hormones decline. In the long-run health expenditures decline.

Economics is Utilinarism operated in Medicine as Quality-Adjusted Life Years (QALY). As a common outcome of BE QALY enables integration of collective policies for the common best. The following collective values are identified:

a) Universal Basic Income (UBI) is a shortcut to equality improving total welfare, because Economic solidarity is a psychological parameter of QALY.

b) The economy can be greened by subsidizing alternatives to fossil energy (ES).

The Paris Agreement 2015 can implement ES. The best preliminary budget for such project is, that it requires a contribution of 0.8-1.2% of GDP in 5 years from each of the industrialized members in accordance with their CO_2 emission. The PA15 is expected to "auction" their funding among green energy projects for the most effective green projects by private and public organisations.

Keywords: neuroeconomics, triune brain, Big5 taxonomy, UBI and sustainable development

Volume 17 Issue 2 - 2026

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Received: March 17, 2026 | **Published:** April 3, 2026

Introduction

Economics studies production, distribution and consumption of goods and services. Economic behavior is supposed to follow a Paradigm of "Bounded Rationality (BR)",[1] but BR is criticized for lacking a diversified scope of economic behavior giving birth to an "Economic Psychology" to bridge Economics and Psychology. "Prospect Theory of Decision-making" has got a Nobel Prize to show how individuals assess their loss and gain prospects in an asymmetric manner,[2] but that`s not a complete alternative to BR. Insecurity on basic Economics makes today international decision- makers call for a new synthesis.[3] In this study a Neuroeconomic Model (NeM) is extended to model Behavioral Economics (BE) guiding individual economic behavior by Utilinarism.[4] Finally, social limitations and complements to BE are discussed.

Method

Neuroeconomics integrates Economics, Psychology and Neurology by neuroimaging and related tools to identify the physiological and neural underpinnings of economic and social behaviors to get more accurate and impartial models of decision-making. The Triune Brain Model (TBM) shows in Figure 1 the basal functional integration of the 3 neurobiological levels of evolution:[5]

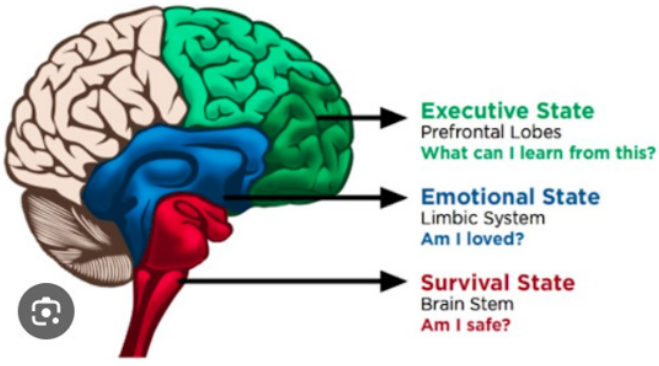

Figure 1 The triune brain model (TBM).

Notes

Evolutionary levels of the brain:

Instinctual Reptilian survival by the Brain Stem Ambivalent emotional responses by the Mammalian Limbic System (LS) Executive human cognitive function on top of Frontal Cortex centers vmPFC and dlPFC as overall integration centers.

TBM has gotten much scientific attention, but is rejected as a direct model of behavior,[6] due to the lack of a model of the internal integration across levels to become operational. Figure 1 shows the centers identified for integration of PFC*LS:

1. Ventromedial PFC (vmPFC) originating intuition[7]
2. Dorsolateral PFC centering cognitive analysis[8]

In the 19th Century recognized Hegel intuitively the basal cognitive dynamics of vmPFC and dlPFC, launching the dialectical method for dynamic cognition:[9]

Thesis - Antithesis → Synthesis by empirical findings Hegel must be acknowledged as a forerunner of a modern neuroeconomic understanding of the core of human thinking as a dialectical process between Intuition by vmPFC and Cognitive Analysis by dlPFC. This dialectical thinking is elaborated to a Model of Behavioral Economics (BE) guiding economic behavior:

1. Model of Behavioral Economics
   - 1.1 Neuroeconomic Model (NeM)
   - 1.2 Behavioral Economics (BE)
   - 1.2.1 Heuristic sensitivity training
   - 1.2.2 Stress-management
2. Discussion of Negative Effects of Liberalist Growth
   - 2.1 Economic Inequality
   - 2.2 Protection of the Ecosystem
   - 2.3 Conclusion of the Negative Effects of Liberalist Growth

Results

A positivist model of behavioral economics (BE)

Neuroeconomic model (NeM)

The functional integration of TBM is illustrated in Figure 2. The X-axis (vmPFC) represents the Limbic System (LS(ANS)), while the Y-axis (dlPFC) is the Frontal Cognition. The convexity of the curvature is demonstrated by Neuroeconomic trials:

a) Exploratory choices combine an open cognition (Y-axis) with low Limbic activation.[10]

b) Risk-aversive choices arise from a high Limbic activation overloading (blocking) Frontal cognition.[8] Later studies differentiate between subtypes of insecurity responses.[11]

Fig. 2 illustrates how the basal cortical balance between LS (ANS) and the Frontal Cortex determines a state with specific individual characteristics discovered by the Antique as the Temper. NeM explains how the individual Temper varies from person to person regarding the functional balance between:

a) Ambivalent Limbic emotions (Fear and Lust) mirroring our biological origins

b) Cognitive PreFrontal Functions

The Neurological rooting of Temper is elaborated below in 1.2.

Further, Figure 2 illustrates a central psychological law of job-related creativity development. The maximal cognitive function (Rationality) is reached at a moderate level of Limbic activation, while maximal Exploration (for creativity) appears at a relatively low level of autonomic Limbic activation. So, NeM illustrates that to unfold our full creative potential, somewhat relaxation is useful.

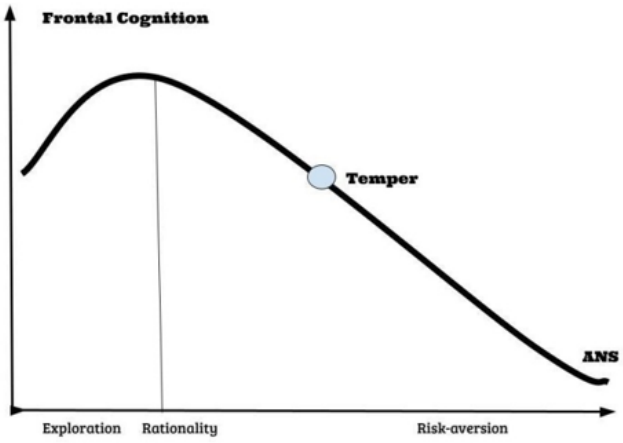

Figure 2 Neuroeconomic model (NeM).

Positivist model of behavioral economics (BE)

A phenotypic study of personality traits identifies 5 different Tempers (Big5):[12] Extraversion (outgoing/energetic vs. solitary/reserved) Openness to new experiences (inventive/curious vs. consistent/cautious) Conscientiousness (efficient/organized vs. extravagant/careless) Agreeableness (friendly/compassionate vs. critical/rational) Neuroticism (sensitive/nervous vs. resilient/confident)

The Big5 Tempers correlate significantly with risk-willingness[13] and have intuitive parallels to the the classical Tempers:

Extravert	Open-minded	Conscientious	Agreeable	Neurotic
~	~	~	~	~
Sanguine	?	Phlegmatic	Melancholic	Choleric

This shows that the 5th modern Temper, Open-mindedness, primarily is a matter of modern cognitive development reflecting the rise of the creative class.[14,15]

The distribution of the Big5 among students in different Academic Majors are often moderate (about 0.5 standard deviation), but especially the share of Open-minded differs strongly among Majors.[16] Table 1 shows the distribution of the Big5 2004 by General risk-willingness and genders as calculated from German data.

BE has an asymmetric distribution of both Tempers and genders where males have relatively few Neurotic and Conscientious, but relatively many Open-minded and Extravert. In contrast, females have relatively many Neurotics, but few Open-minded and Extraverts. The most typical Temper is to both genders Agreeables. This shows unambiguously that the diversity of human economic behavioral patterns is far larger than presupposed by the BR dogma!

The largest behavioral variant identified by empirical BE-research is Nudging,[18] where a person moves other persons in a predetermined direction by small friendly "Nudges" without any use of moralist norms. The mental dynamics of this type of personal interaction is explained by the large share of "Agreeables" in Table 1.

Citation: Larsen T. Behavioral economics (BE): a neuroeconomic alternative to the paradigm of bounded rationality. *J Psychol Clin Psychiatry.* 2026;17(2):68–73. DOI: 10.15406/jpcpy.2026.17.00855

Table 1 Behavioral economics (BE)

Correlation w/ risk-will	Negative correlation		Positive correlation		
Temper (Dohmen score)	Neurotic (0-2)	Agreeable (3-4)	Conscientious (5-6)	Open-minded (7-8)	Extravert (9-10)
Males (%)	5	17	5	9	8
Females (%)	17	20	8	3	2

Source: Recalculation of German data based on Dohmen et al.,[3] & Dawson.[17]

General risk-willingness correlates with income.[19] Neurotics and Agreeable correlate negatively with income, while there is a significant positive correlation between income and Conscientious, Open-minded and Extraverts.

In all, BE serves the development of Human Relations (HR) originated by Mayo's Hawthorne Studies (1920s) focusing work efficiency by job-relations by good mutual understanding of colleagues rather than just financial and physical incentives!

Heuristic sensitivity training for collaborative skills

Temper is a person's non-reflected subjective comfort level with uncertainty and potential loss when pursuing a reward. High risk-willingness means being more likely to take bold actions, while low risk-willingness leads to safer choices to avoid failures. Males are more risk-willing than females[17] and asking people about their willingness to take risks "in general" correlates all significantly with gender, age, height, and parental background.[18] A good professional collaboration i.e. regarding human relations in management (HR) requires a minimal mutual psychological understanding beyond the BR Dogma presupposing general rationality in economic behavior. The Dohmen Scale orders the Big5 Tempers by general risk-willingness.[13] This enables a simple heuristic sensitivity-training i.e. in HR on the Tempers helping persons to better job-related collaboration (Figure 3).

Figure 3 Dohmen Scale 0-10 on general risk-willingness.

The Sensitivity Heuristic is preliminary tested by Guest Lectures on BE at Niels Brock Business School in Odense Dk, where Teachers and students replied to a Questionnaire. Comparing the distribution of the Dohmen Score of the participants with the distribution of BE showed no important difference: Half of the respondents were Risk-averse, while the other half parted between Rationality and Risk-willing. The average score was 6,5 indicating an average of moderated Risk-willingness. The following Heuristic is recommended for your sensitivity-training:

Heuristic for sensitivity-training

1. Mark your own general risk-willingness on the Dohmen Scale and discuss with yourself, how does the indicated Temper in Table 2 match your self-recognition?
2. Go on asking friends and colleagues to indicate their position on the Dohmen Scale, too, and compare their answers with what you expected!
3. Over time note all the replies from other persons in Excel comparing their replies with the distribution in Table 1.
4. Apply the Heuristic discretely in your job-relations in a simplified version:

(i) 0-3 indicates a Risk-aversive Temper.

(ii) 4-6 indicates a Rationalist decision-maker 7-10 indicates a Risk-willing Temper.

Table 2 Regional comparison of welfare by social system 2025

Parameter	USA	EU	China	All World
System	Liberalist democracy	Center-oriented democracy	Socialist market-economy	Various types of constitution
Population PPP per capita (GINI Coefficient)	350 mio.	450 mio.	1.450 mio.	8.050 mio.
Household consumer rate	80.000 USD (42%) 70%	64.000 USD (32%) 55%	45.000 USD (46%) 40%	23.000 USD (65%) 48%
Greening policy	No long-term plan to fulfil PA	Aims to fulfill PA No plan so far	Aims to fulfill PA No specific plan	Existing plans do not fulfill PA
Mental disorder	19%	17%	15%	12%
QALY (Years)	**77 Years**	**80 Years**	**77 Years**	**70 Years**

Source: Data extracted directly from published statistics in EconLib, Medline and PsychInfo.

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Stress-management by in-depth relaxation

The rise of the creative class is part of the market-based economic growth.[13,14] A simultaneous negative outcome is a rising load of job-related stress. WHO warns that Depression by 2030 will become the most heavy health burden.[20] Many in the workforce may simply choose to retire early or reduce work hours to reduce their stress-level and improve health and life-expectancy. Worldwide, Job-related epidemic stress accounts for 2% of GDP, causing 3 million deaths and another million disabilities. The annual loss is estimated to be 100 million QALY, but is expected to triple before 2050.[21]

A relatively simple procedure for stress-management is meditative in-depth relaxation.[22] Regular meditation increases human flexibility releasing subconscious stresses between the attention and Origo as illustrated in Figure 2. Already 3000 years ago, Indo-Europeans discovered mantra-meditation as means to reach Origo (Nirvana) freeing imagination as reported in the Bhagavadghita. Modern secular mantra-meditation is practiced in a relaxed sitting position on a simple chair in a quiet place dissolving thoughts by a mantra. The long-term effects of a modern setting is investigated in a series of experiments at Harvard Medical School:[22]

(i) Significant decline in the stress hormone (plasma cortisol).

(ii) A meta-analysis finds that regular relaxation exercises complement physical fitness as a health activity that dissolves stress and anxiety.

(iii) A 14-year, pre- and post-intervention study retrospectively assessed government payments to physicians for treating the TM and comparison groups. Payment to physicians declined 5-13% annually compared with subjects over 6 years.

(iv) The psychology of meditation summarizes in "Psychology of Silence".[23]

The primary individual advice on mental health is self-control or stamina based on physical fitness.[24] An additional modern device for subjective control of the technical effect of meditative in-depth relaxation is Neurofeedback i.e. by a simple Galvanometer. Such control of the personal meditation instruction by an experienced meditation teacher is especially relevant today, where the mutual knowledge between teacher and student often is relatively poor.

Discussion of the negative effects of liberalist growth

Market-based growth has driven the Western world for 200 years, redoubling QALY from 40 to years, but these years negative growth-effects rise exponentially. A negative growth effect is the epidemic job-related stress, addressed above in 1.2.2.

A classical issue in market-driven industrialization is the inequality rising from large companies with extraordinary success, which is addressed in 2.1.

The climate damage is another exponential rising negative growth effect, related to global warming following from the rising emission of CO_2 to the atmosphere. This is addressed in 2.2.

The overall prospects of both positive and negative effects are assessed in 2.3.

Economic inequality

Economic inequality affects us as a society - not just as individuals! Inequality is measured by the Gini-coefficient as a percentage between 0% (all persons have the same income) and 100% (1 person has all income). Economic inequality is studied in a Dutch study with 1091 random respondents. They had a mean value per QALY of €24,500, but varied significantly from €5000 in the lowest to €75,400 in the highest income group.[25] A Finnish trial on Universal Basic Income (UBI) documents that social clients get an increased job-motivation among low-income groups.[26] In all, this documents that the QALY effect of a specific pecuniary subsidy is far more positive among lower-incomes than the corresponding negative effect among high-incomes. What`s then the best distribution of income?

The industrialized world has two leading variants of democracy (USA and EU), and the socialist Chinese economy. The US is a liberalist democracy, where the Democrats never have gotten enough long-term economic-political impact to build a long-term system of social security, like the EU. When a Democrat US-presidency has succeeded in making social welfare reforms, they become annulated by the next Republican-presidency. For instance assured the Obama Reform of Healthcare free healthcare also to the poorest Americans, like in the EU. Today the Republican Trump` Administration counteracts this strongly, even by closing-down the Federal Administration for months. In the same way, the Trump` Administration counteracts the Biden Plan for greening the US Economy 2050.[27] Such a Zig-Zagging in the economic long-term policy challenges international collaboration i.e. implementation of the Paris Agreement 2015 (PA15). In order to compare the dominant forms of industrialization, Figure 4 orders the most important economic ideologies on a scale from full entrepreneurial freedom to strong central managed economy.

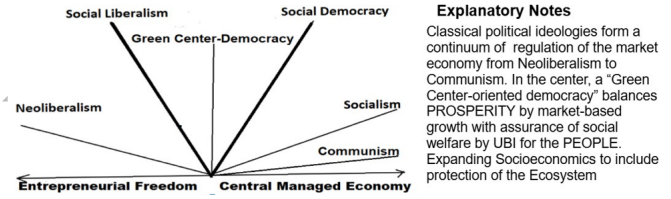

Figure 4 Spectrum of democratic political ideologies.

Table 2 shows key figures on the leading industrial regions. Although the US has the highest PPP per capita, the EU has a lower Gini-coefficient (32% vs. 42%) and the QALY is 3 years higher in the EU than the USA. Further, China with only a third PPP per capita compared with the US has already the same level of QALY. The share of mental disorders is higher in the US than in both the EU and China.

In all, European social democracy is better for the population than liberalist American democracy, and there is no evidence that the difference in Gini-coefficient between the EU and the US, makes a difference in the investment level. It`s an open question whether the European social democracy or the Chinese socialist economy is going to deliver the best QALY to the population in the long-run. The EU has so far an advantage to China regarding both economic equality and QALY, however, the strong central management of China has enabled it to maintain a low level of household consumption with a high investment rate and rapid growth. However, the European advantage in QALY may be minimized simply by Chinese redistribution reforms. Regarding the optimal level of inequality in relation to growth, a Gini-coefficient >30% does not limit investment in any significant way.

The European superiority regarding population welfare (QALY) seems to rely on stronger economic solidarity, which in the EU implies collective finance of public services such as healthcare, education and social care. Social European democracy was built step-by-step during the last 100 years. Is it possible in the light of these European societal experiences to find a shortcut to a social security system that for example could elevate QALY in the US (and eventually too China)!

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More Nobel Laureates recommend a tax-financed Universal Basic Income (UBI) at the level of relative poverty as a shortcut to social long-term security increasing total QALY, see InfoBox. This makes economic solidarity a psychological parameter of QALY.

Infobox on the history of universal basic income (UBI)

Universal Basic Income (UBI) and related labels, like Citizen or National dividend, Social credit, Demogrant (grant based on) or Negative income is 50 years old, and "Erosion of Income Security" revives today the motivation for UBI. At the end of the 60s, there were four experiments on UBI in the United States, all in the form of negative income transfers, indicating a moderate reduction in work effort (Females: 17%, Males: 7%). This has moderated the mainstream interest in UBI in the US. A Canadian experiment addressed rural poverty: Over 4 years, an average family was guaranteed an annual income of 1.000 USD per month, which was considered a success. A recent test of UBI in Finland showed a positive effect on work motivation among low incomes.[25] Further testing of UBI is recommended.

Protection of the ecosystem

An updated forecast by IEA expects that the national plans for climate protection will reduce the global CO_2-emission by a third to 25 Gt per year in 2050.[28] However, such a reduction is not at all enough to fulfill the Paris Agreement (PA15), because the rise in global CO_2 emission has been even faster than predicted in 2015.

A study by the World Economic Forum (WEF) warns that intensified natural disasters by global heating by 2050 will cost $12.5 Trillion USD (10% of global GDP) and cause the loss of more than 2 billion QALY per year and raising global health inequities in the most vulnerable populations, including women, youth, elderly, lower-income groups and communities.[29] Another macroeconomic study expects even worse climate damages, calculating the damages and derived costs on the base of local national changes in temperature, where others have calculated these effects on the base of the annual global changes in temperature.[30]

Mainstream economics recommends to green the economy by a CO_2 Tax (ET) in accordance with the Nobel Awards to Pigou 1920, Norton 2018 and case studies.[31] However, atmospheric heating by CO_2 has no borders and a national ET loads the national competitiveness In an internationalized economy with free international trade. The Biden Presidency introduced a new Western strategy, to make the US carbon neutral in 2050 by subsidizing non-fossil energy (ES).[27] Already, China subsidizes non-fossil energy as electric cars. ES would, too, help the West compete with China. Subsidizing alternatives to fossil energy (ES) at the same level as an ET:

(i) ES must be financed by taxpayers, but an ET on companies/ institutions is, too, going to be pushed-over on ordinary citizens.

(ii) The gross starting budget of ES is low, grows over time, and must be limited to the life-time of the subsidized production.

(iii) A broad international ET peaks the budget from start and declines over time.

Other important global threats to the Ecosystem are pollution of earth and water by fertilizers used by modern HiTec-agriculture. This implies that alternative forms of ecological agriculture should be subsidized, too.

Conclusion on the prospects of growth and outline of a possible environmental protection strategy

The Global Review of Energy states, p24:[27] "To enable Climate resilience governments, civil society and the private sector must make inclusive development choices that prioritize risk reduction, equity and justice across governance levels, sectors, and timeframes"!

The market-based economic growth has during the last 200 years redoubled QALY in the industrialized world from 40 to 80 years and a logarithmic relationship exists between growth in GDP per capita and QALY.[32] In 2035, the QALY effect of market growth is expected to be 1 extra QALY per 8 years corresponding to 1.000 Million extra living years per year. By correction for disabilities, it declines to 800 mio QALY per year. Table 3 lists the expected global total of gains and losses in 2035:

Table 3 Expected marginal annual economic growth 2035

Growth factor	Mio. QALY p.a.	References
Market-based growth	**800**	Calculation from data in UN Development Programme 2005[32]
Job-related stress	**-200**	Calculation of global loss of QALY based on data in International Labor Organisation[21]
Climate danage	**-600**	Calculation from data in World Economic Forum[29]
Global net growth	**0**	

After 2035, the global economic net growth is going to turn negative, outdating the monodimensional liberalist growth model that has dominated the West in Centuries. Greening the economy by ES must cover the difference in costs per energy unit between conventional carbon-based energy and renewables by wind and sun as well as among different sectors. The appropriate term for such comparison is Levelized Cost of Energy (LCOE) that includes lifetime capital, operation, maintenance, and fuel costs, divided by total energy output. From 2010 to 2024 LCOE for battery- storage declined by 93%.[33] In the real world both the price of conventional and that of non-fossil energy varies a lot between countries as well as between sectors calling for a flexible implementation strategy between central and local levels. The global center for such implementation of ES has a primary candidate in the PA15 (Table 3).

The best wind/solar projects are today nearly as economically effective by LCOE as conventional energy projects.[33] This implies that an incentive of 50 USD per avoided ton CO_2 emission must be enough to accelerate a large-scale transmission from conventional to non-fossil energy. The annual CO_2 emission is 37 Gigaton.

In accordance with IEA,[28] an extraordinary reduction in the actual CO_2 emission besides existing PA15 projects by 15 Gigaton, is sufficient to implement the PA15 plan and turn-around the climate crisis from a negative to a positive path.

To get a preliminary assessment of such project with an insecurity of at least +-20%, a budget for substitution of 15 Gigaton CO_2 is estimated as follows:

$15 \times 10^9 \times 50$ USD = 750 Billion USD ~ 0.75% of the global GDP

The industrialized world (creating the problem) represents 67% of the global GDP and it seems fair that they, too, pay the costs for the non-industrial countries.

So, the PA15 members have to pay 0.8-1.2% of their GDP in 5 years (besides already planned actions) to turn around the climate crisis in accordance with the IEA. With a 5-year horizon, the Members of the PA15 must together extraordinarily finance 150 Billion USD per year. Such a budget is within the range, but on the limit, of what can be handled by international institutions even in such an extraordinary situation. Besides, a lot of progress in green energy technology will arise, too.

Getting such an extraordinary funding of 150 Billion USD in 5 years, the PA15 must "auction" it among private, national and regional actors that offer the most effective alternatives to fossil-energy. Such an international political investment project has by IEA,[28,29] a sensible rate-of-return by savings on climate damages. However, unfortunately the link between investment and returns is not preknown in detail.

The poor economic solidarity in the US and the global economic significance of China implies that the Postwar key alliance between the US, Europe and other democracies must be re-evaluated and expanded.

Acknowledgments

None.

Funding

None.

Conflicts of interest

The author declares that there is no conflict of interest.

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