Potential Canvas : Space-Time Structure of Growth and Development

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Abstract

This paper has tried to establish a potential measuring scale for governing policies within the framework of space-time structure in the general relativistic viewpoint of physical sciences. It enables us to measure the outcomes of governing policies on the basis of decrease in potential defined through the curvature of space-time like potential canvas framed with underlying scales of development. It provides a tool to the planning bodies to monitor and control the economic and social development in their respective potential canvas along with checks and balances for flow of money in an economy through the curvatures of potential canvas of economic development.

Keywords : **econophysics, growth & development, potential canvas, economic curvature**

JEL Classification: A12, C6, C16, C31, C81

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The vast difference in growth and development in developing countries has created the situation of policy vacuum, that is, policies with invisible targets. This policy vacuum fails the proper implementation and monitoring of the policy itself. This is mainly because the growth oriented governing policies are unable to provide relevant development as required because of this vast difference. For example, India, with a total area of 32,87, 590 sq. km. had a population of 1210193444 as per the 2011 census. This was the second highest in the world. India had GDP at purchasing power parity (as per 2014 estimate) equal to \$ 5.425 trillion (third highest in the world) and at nominal rate, this was equal to \$ 1.996 trillion (tenth highest in the world) and should have provided per capita income of \$4307 at purchasing power parity and \$1584 at nominal rate, respectively. The estimated per capita income was enough to fulfil the basic needs of individuals and eradicate poverty. However, it is not as expected, the vast income gap (as represented by 2010 Gini's coefficient for India with a value of 33.9) results in heterogeneous and non-uniform development of the people, which can be clearly seen from the 2013 Human Development Index Report which ranked India at the 135th place with an index value of 0.586 (Ranis, Stewart, & Ramirez, 2000).

It is mostly not the problem with governing policies, but the failure in their proper implementation due to a policy vacuum (Ruffin, 2001). The most critical problem in India is that despite the fact that development is heterogeneous and non-uniform due to improper implementation, policies are directed homogenously and uniformly. This can be due to various reasons, including political instability, lack of federal coordination, and so forth. This leads to intense corruption as the supply of surplus resources is major reasons of temptations for corruption.

To overcome such a problem, this paper introduces space-time structure like potential canvas of development, which initially induces curvature with underlying scales of development in the region under consideration. The

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Figure 1. Illustrating the Drain of Development Resources Through the Curvatures of Potential Canvas

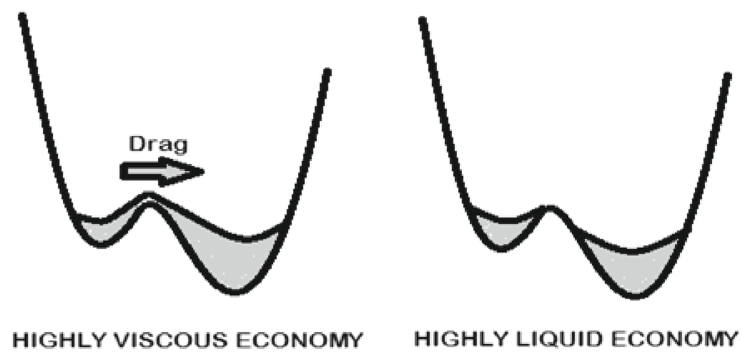
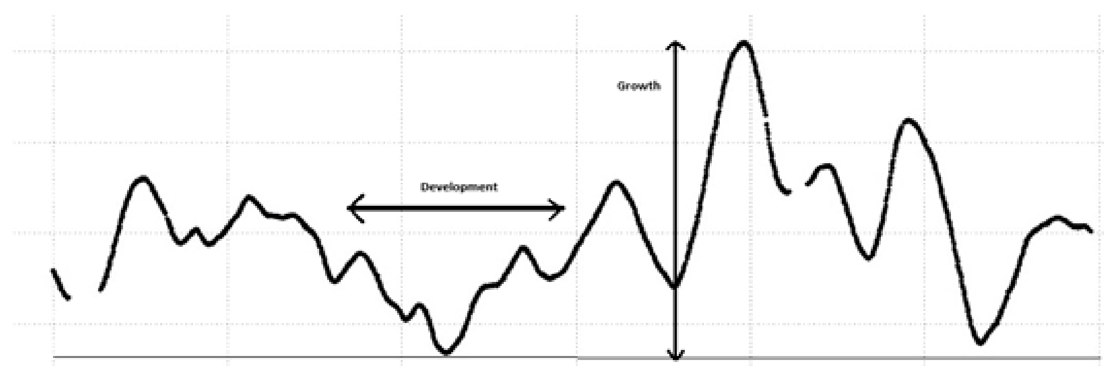


Figure 2. Illustrating the GROWTH and DEVELOPMENT Measures Depicted by the Curvatures of Potential Canvas



governing body of this specified region acts as an economic and social cloud which sheds its policy on the continuum of the potential canvas in a controlled manner such that the drain of resources for development is directed towards targeted population defined through potential curvature in canvas. Government controls the policy shed by controlling the viscosity and liquidity of economy as illustrated in the Figure 1. A highly viscous economy with low liquidity targets the heterogeneous and non-uniform potential regions mostly lying at the depth of the curvatures in potential canvas, while a viscous and highly liquid economy targets a wider region with homogenous and relatively uniform potential decay.

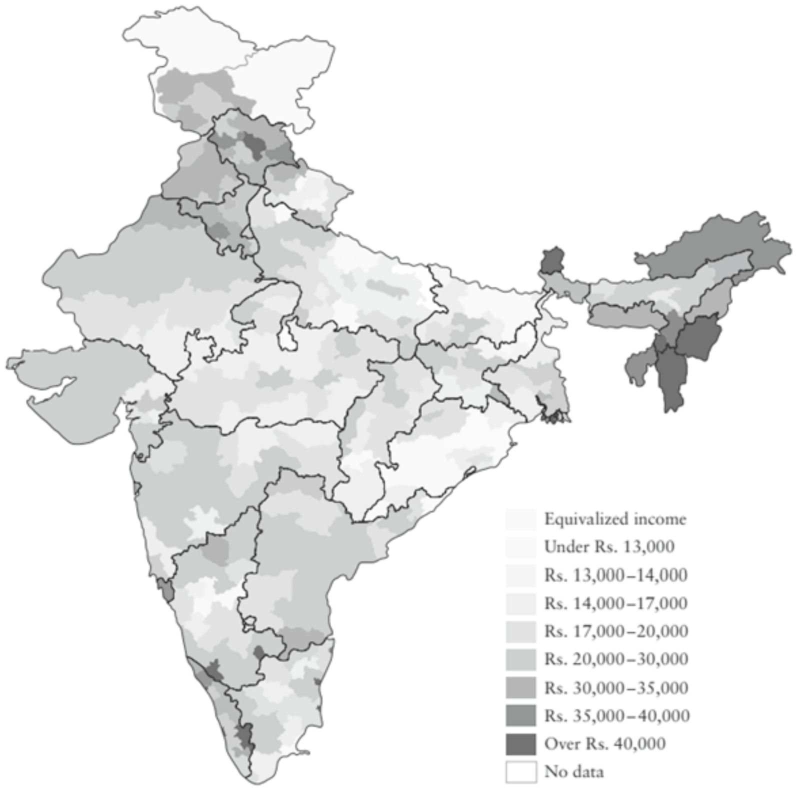
What is Growth and Development?

(1) Growth: It is the increase in parameter at a specific point respectively on a vertical scale. For example, in terms of income inequality, the increase in income at a specific point or region is *growth*.

(2) Development : It is the uniformity in distribution of a parameter over a wide region measured on a horizontal scale. It is mainly measured through the variance in distribution. For example, the homogeneity in distribution of income in a specified region is *development*.

Hence, as per Figure 2, development is a wider phenomenon which tends to bring uniformity and homogeneity in the potential distribution along the canvas unlike growth, which is more of non-uniform and heterogeneous in narrow regions.

Figure 3. Vertical and Horizontal Income Inequalities in India



Development Potential and Curvature of Potential Canvas

The development potential for potential canvas varies with the considered universal set such as economy, environment, demography, and so forth. In this paper, I would explain the methodologies with an example of income inequality.

The Figure 3 represents the average income level of people at the district level. The same could be done at more localized levels through census surveys. This two dimensional distribution of incomes on a surface could be converted into three dimensional potential canvas curvatures by following rules (Geroch, & Horowitz, 1979).

(1) Calculate the difference between maximum and minimum income levels of the considered universal set and divide it into number of units which can be undertaken by respective governing bodies through minimum support programmes.

Minimum Support Programme: It is the minimum amount of development package which can be provided by governing bodies to a specified localized region at specified time without affecting liquidity at a wider region.

(2) With the scale of division calculated, plot the surveyed measurements or observations. This gives curved sheet similar to space time curvature as shown in the Figure 4. The depth of the curvatures in Figure 4 define the vertical potential, that is, the growth deficit, and measures the economic inequality. The steepness of these curvatures defines the horizontal potential, that is, the development deficit, and measures social inequality.

Once we have derived the curvature plotted on the potential canvas, we can apply the measures to the curvature

Figure 4. Potential Canvas Curvature

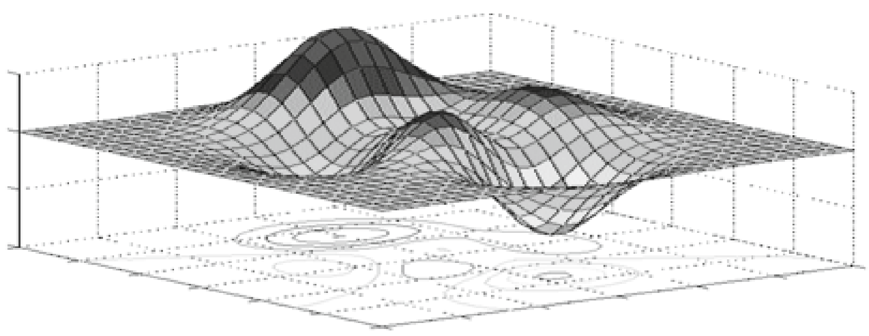


Table 1. Comparison of Components of Space Time & Potential Canvas

Space Time	Potential Canvas
1. Riemann Curvature R^{a}_{bcd}: Measures to what extent the metric is not isometric to the flat Euclidean space. It measures the failure of parallel transportation.	**1. Curvature Tensor (C_{Tabcd}):** measures to what extent the income distribution is not isometric to expected income equality in a specified region. It measures the failure of homogenous development.
2. Ricci Tensor $R_{ab} = R^{c}_{acb}$: measures the amount by which the volume of a geodesic ball in a curved Riemann manifold deviates from that of a standard ball in Euclidean space. It is the trace of curvature tensor.	**2. Curvature Trace ($C_{t\mu\upsilon}$ = Trace [C_{Tabcd}]):** measures the trace of curvature of the canvas i.e. measures the potential of development with respect to growth.
3. Ricci Scalar $R=g^{ab}R_{ab}$: When positive at a point, itsuggests thata ball around the point has a smaller volume than a ball of equal radius in Euclidean space.	**3. Curvature Potential ($C = g^{\mu\upsilon}\, C_{T}\mu\upsilon$):** measures the scalar point potential which when high represents the steep slope of the curvature i.e. high gradient and vice versa. It measures the failure of uniformity in development.

Table 2. Analogous of Four Indices for the Space Time Architecture of Potential Canvas

Indicator	Name of the parameter (q)	Potential Approach	Required Trend
a	Per capita Income	Growth	Increase
b	Employment - Workforce Ratio	Development	Increase
c	Purchasing Power Parity in specific region	Development	Decrease *
d	Workforce - Population Ratio	Growth	Increase

* We want the purchasing power parity to decrease in a region because it wrongly reflects the effect of inflation in a more developed region and weakens economic development.

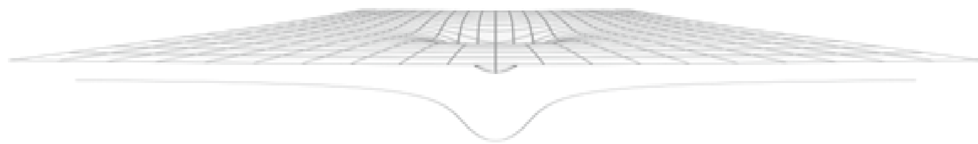
of the potential canvas just as these can be applied to the space time curvature of physical sciences to have an insight into to the econophysical image of the economy. The relative comparison with respect to income inequality can be defined (Wicklin, 2010) as depicted in Table 1.

Derivation of Curvature Components from Statistical Tools

Taking the example of income inequality, we can determine the exact situation of income inequality through the four parameters depicted in the Table 2.

Metric Tensor : The four dimensional covariance matrix Σ and correlation matrix ρij provide the covariant and contravariant metric tensor for our potential canvas. The covariance matrix defines the divergence in data

Figure 5 . Curvature Produced in Potential Canvas due to the Action of Specified Tensors



elements of the respective observables similar to the covariant metric tensor in general relativity, which projects onto normal lines in the coordinates hyper plane ; whereas, correlation matrix defines the degree of relation among the independent parameters similar to contravariant metric tensor in general relativity, which projects onto the coordinate axes. Both the defined potential metrics attain singularity when the parameters are independent of each other. The metric representation of the same for n^{th} order is:

$$\Sigma = \begin{bmatrix} E[(X_1-\mu_1)(X_{1-}\mu_1) & E[(X_1-\mu_1)(X_1-\mu_2)] & \dots & E[(X_1-\mu_1)(X_n-\mu_n)] \\ E[(X_2-\mu_2)(X_{1-}\mu_1) & E[(X_2-\mu_2)(X_2-\mu_2)] & \dots & E[(X_2-\mu_2)(X_n-\mu_n)] \\ \vdots & \vdots & \ddots & \vdots \\ E[(X_n-\mu_n)(X_{1-}\mu_1) & E[(X_n-\mu_n)(X_2-\mu_2)] & \dots & E[(X_n-\mu_n)(X_n-\mu_n)] \end{bmatrix}.$$

Illustration of n^{th} order covariance matrix :

$$\rho_{ij} = (\Sigma^{(\text{diag})})^{-\frac{1}{2}}\,\Sigma = (\Sigma^{(\text{diag})})^{-\frac{1}{2}}$$

Relation between correlation matrix and covariance matrix :

$g^{\mu\nu} = \rho_{ij}$ Contravariant Metric Tensor

$g^{\mu\nu} = \Sigma$ Covariant Metric Tensor

To define the curvature tensor, we need to solve the affine connections on the surface which rolls the affine tangent plane from one point to other. As it does so, the point of contact traces out a curve in the plane which is considered as development with invariant torsion from potential and the associated curvature. It is being solved in a way similar to the calculations of Riemann tensors by taking the measures of different dimensions defined by the various indices of the tensors in general relativity with the values of different parameters considered, providing us with a smooth potential surface as given in the Figure 5. The metric tensors can be visualized as depicted in the Figure 6 and Figure 7.

Christoffel symbols as derivatives of the metric tensor (given by Dullemond, 1991) :

$$\Rightarrow \Gamma_{cab} = \frac{1}{2}\left\{\frac{\partial g_{ca}}{\partial q^{b}} + \frac{\partial g_{cb}}{\partial q^{a}} - \frac{\partial g_{ab}}{\partial q^{c}}\right\}$$

Curvature Tensor (C_{Tabcd}):

$$\Rightarrow C_{Tabcd} = \Gamma^{a}{}_{bc,d} - \Gamma^{a}{}_{bd,c} + \Gamma^{\mu}{}_{bc}\,\Gamma^{a}{}_{\mu d} - \Gamma^{\mu}{}_{bd}\,\Gamma^{a}{}_{\mu c}$$

Curvature Trace (C_{Tab} = Trace [C_{Tabcd}]):

$$\Rightarrow C_{T\mu\nu} = \frac{1}{2}\,(g^{\mu a} + g^{\mu c}) + \frac{1}{2}\,(g^{\nu b} + g^{\nu d})\,(\mathrm{C}_{tabcd})$$

Figure 6. Effect of Correlation Matrix

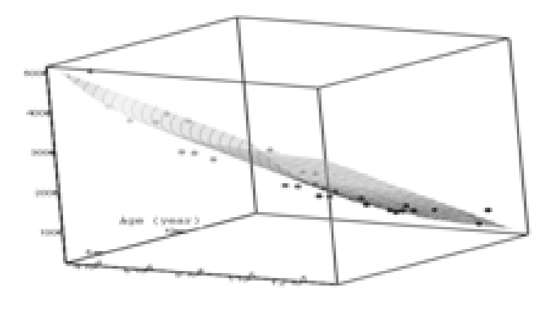
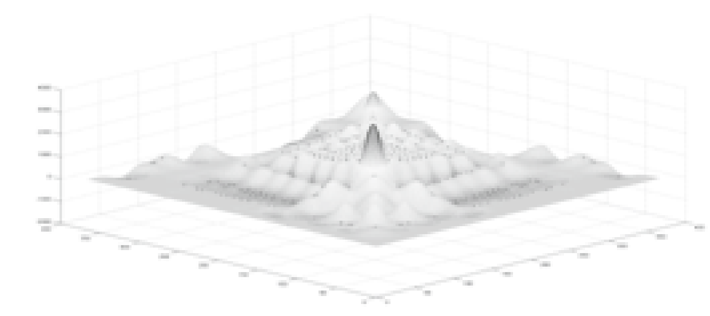


Figure 7. Effect of Covariance Matrix



In the derivation of curvature trace represented in Figures 6 and 7, I try to merge the parameters on the basis of relative approximation, that is, parameter a and c can be merged to give a parameter μ , for example, if the per capita income a for a region is \$1000 and the purchasing power parity c in that region is 1.7, then the corrected or real per capita income (μ) in that region is \$1000 * 1.7 = \$1700.

In developing countries, it is a prominent factor as equal amount of money has different purchasing power with varying locations. Sometimes, the difference is very high when compared between rural and urban regions. Similarly, b and d can be merged to υ. Calculation of per capita income does not take the workforce into consideration for homogeneity, but for getting the potential of development in a specific region in terms of per capita income, we need to take it under consideration. For example, if the per capita income of a region is \$10000, and the total population of that region is 1000 with a workforce of 500 out of which only 100 are employed, then we have a potential depth of \$40,000, which could have been earned if all the people in the work force were employed. Thus, for homogenous development, we should correct the per capita income in terms of potential, that is, \$10000 * 0.2 * 1.7 = \$3400 and the corresponding per capita income would be \$34 instead of \$100 without potential adjustments. The value can be better defined by the curvature trace, which would consider the correlation of the parameters to trace the potential.

Curvature Potential ($C_T = g^{\mu\nu} C_{T\mu\nu}$)

$$\Rightarrow C_T = g^{\mu\nu} C_{T\mu\nu}$$

Thus, our potential field equation for canvas potential would be:

$$\Rightarrow \quad C_{T\mu\nu} - \frac{1}{2} g_{\mu a} C_T + g_{\mu\nu}\Lambda = \frac{P}{a^4} T_{\mu\nu}$$

where,

$T_{\mu\nu}$ = policy potential tensor.

$$T_{\mu\nu} = \begin{matrix} T^{00} & T^{01} & T^{02} & T^{03} \\ T^{10} & T^{11} & T^{12} & T^{13} \\ T^{20} & T^{21} & T^{22} & T^{23} \\ T^{30} & T^{31} & T^{32} & T^{33} \end{matrix}$$

Colour Code	Description
T^{00}	Development potential density.
T^{0i},T^{i0}	Development momentum density.
T^{ii}	Gradient of development.
T^{ij}	Development momentum flux.

$\Rightarrow$ Λ : Effect of corruption potential or effect of dark economy.

⇨ Here $\frac{P}{a^4}$ is the binding strength of proportionality between the policy's effect and the potential canvas.

P : Policy Potential Index is an expected percentage measure to be devised at initial formation of policy by the policy makers themselves as a ratio for effectiveness of the policy and they always try to keep it higher. It is calculated as:

$$P = \frac{Impacted\ Targeted\ Population}{Total\ Targeted\ Population} * 100\%$$

α : is the rate of autocatalysis which denotes people's participation in implementation of policies.
a^4: is the four dimensional participation of population for distribution of growth for development. This can be measured by surveying the social and scientific temper of the people in a specific region by a psychological questionnaire. The fourth dimension is time factor, which is related to the result of positive and negative effect of participation of people, and it may vary the time frame for implementation, resulting in an increase or a decrease in potential. A delayed implementation increases the potential.

Thus, we can say that growth can be eroded off to development, that is, growth can be traded off with development and vice versa. The trade-off can be achieved by pumping liquid money in form of subsidies, bailout, and so forth. While treating the potential canvas statistically, we can have the induced effect of auto correlation and auto covariance. This can be geometrically detected from the potential canvas as :

Auto Correlation => It will have the form of *Waveforms* and is *Growth – Oriented*.
Auto Covariance => It will have the form of *Spectrum* and is *Development – Oriented*.

We can define the situation of liquidity trap, where below a critical rate of interest, infinite amount of money can be stored, like a gravitation pit in physical science which requires the velocity of the object to cross the critical escape velocity to escape from the gravitational effect of earth. Earth is a closed system, if we ignore the radiations. The rate of interest represents the porous nature of potential canvas that can soak up infinite money units if the balance between liquidity/viscosity and permeability is disturbed.

Permeability can be defined as:

$$Permeability = f\,(purchasing\ power\ parity) = f\,(\frac{1}{viscosity})$$

The effect of different fundamental forces except the gravitational potential which defines the structure of potential canvas as explained above can also be visualized through the effect of different entities in potential canvas.

Strong Force => when groups of rich or poor cluster together.

Weak Force => when a rich loses his wealth and is to be removed out of the cluster, the rich is to join the cluster of the poor, or a poor gains wealth to leave out the cluster of the poor and joins the cluster of the rich.

Electromagnetic Force =>The rich attract the poor for their requirements and vice versa. Similarly, the rich repel rich in a competitive environment and vice versa.

In comparison to the methodology defined by Wicklin (2010), this paper enhances the conversion methodology between correlation and covariance matrix with homomorphic mapping between the structural definitions of potential canvas and the components of general relativity. With reference to the Ruffin (2001), the principle pertaining to human growth and development provides the framework to represent the distribution of development potential on two dimensional canvas, but it lacks the insight into the localized potential and dynamics of interaction between growth and development. The framework of potential canvas is an approach to overcome the stated problem by providing more dimensions for analysis. The report on *Economic Growth and Human Development* provided the data for determining the potential vector for modelling the potential canvas (Ranis et al., 2000).

Research and Policy Implications

(1) This research provides localized monitoring system with an insight into the decay of potential. It helps to quantize the development process in terms of potential distribution relating to different indicators.

(2) The various measures of potential canvas helps to control the flow of economic packages provided by the different development policies of the government, and establish directed channels to optimally utilize resources. It helps to minimize the policy vacuum and can prevent failures of policy implementation.

(3) In terms of research, potential canvas provides the instruments to apply the econophysical tools in policy formation, implementation, and monitoring phases, and it provides a different analytical method. It enables the instrument formed through law of relativity to analyze the implications of policies.

(4) The independent component sets in calculation of curvature provide the potential vectors to model different field analysis.

(5) The various measures of potential canvas also helps the policy framers in providing more efficient policies and in controlling deviations in a runtime environment by minimizing the policy vacuum.

Conclusion

With the analysis of potential canvas, we would have a more certain targeted approach with less probabilistic divergence as we have confined ourselves to a probability sphere of less radius associated with localized potential. It also provides us a distinct view of analyzing growth and development in a country or at a global level or even in more localized regional spaces. The more localized approach reduces the difference between growth and development (Afonso & Martins, 2010). The best approach of this model is the consideration of people's participation on the basis of their social and scientific temper, which is generally observed to be found in people with surplus economy and their level of development, which comprises of literacy (level of education), innovative approaches like how much their decisions are inspired by their caste, religion, and so forth, which could be derived from a psychological survey of the region.

The smooth curvatures in potential canvas provide a path for flow of development programmes which can be considered to be fluid in nature moving through the depths of potential canvas and can be controlled by changing the liquidity of the economy which guides policies. The important point to note is that the localization of policy is inversely related to the liquidity of the economy as the viscosity of less liquefied fluid drags it to the lowest points of the potential well, that is, depths of the curvature which provide mechanisms for heterogeneous development, while fluid with more liquidity fragments at potential curvature at any levels irrespective of its depth and provides a mechanism for homogenous development.

Limitations of the Study and Scope for Further Research

(1) The potential canvas provides a scientific platform for econophysical analysis of policies and their implications, which in this paper is limited to the usage of the principles of general relativity. It provides scope for further enhancement of the methodology to include different physical treatments in accordance with the global structure of potential canvas.

(2) The potential canvas also provides the initial monitoring system of an economic packages flow and distribution of growth and development, which can be innovated to include dimensions of development with different sets of considered parameters.

(3) It provides the opportunity to frame new economic models to fit the structural framework of potential canvas, which can help in estimating the singularity and criticality of an economy, which may be in different phases of slowdown, boom, and depression.

(4) The combined analysis of different potential vectors helps in estimating the unified development index, which can be used to improve the policy potential index.

(5) The structure of potential canvas includes the dimension of time analogous to the space-time structure of general relativity, which helps to include the dynamics of policy implementation, and it provides runtime improvising of the policy framework.

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