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# Substitutes and complements – the curious case of poverty measure

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# Substitutes and complements – the curious case of poverty measure[1]

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**Abstract**

*Since the 1976 seminal paper by Amartya Sen on axiomatic characterization of poverty measure, researchers have come out with poverty measures with better properties than the simplest measure, the head count ratio (HCR). However, attempt to substitute the HCR has not succeeded given that the HCR remains till date as the dominant headline indicator in policy, media, and political discourse, and for public at large. This note argues that the part of the problem lies in the fundamental intension to 'substitute' the HCR with better indicators. We propose to depart from this conventional approach in indicator research and attempt for indicators which could complement. This approach can lead to having measures exclusively for the poor complimenting the overall poverty measures that are meant for the entire population. The note shows indicators like Income gap ratio, which fails on most counts as an overall poverty measure, turns out to be a fairly good measure of poverty of the poor.*

**Key words**: Complementary poverty measure, Poverty of the poor, Head count ratio (HCR), Income gap ratio (IGR), Poverty gap ratio (PGR), Axioms of poverty measure.

JEL codes: D63, I32, I38

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## 1. Introduction

There are multiple measures to assess poverty of any society. The method for finding goodness of any measure has two essential steps.[3] First, the 'desirable properties' (or axioms) that any poverty measure should satisfy are outlined. Next, the efficacy of the measure is tested in terms of the axioms it satisfies. A measure is considered superior to another if it is better in terms of satisfying the axioms. However, the better measures need not emerge as the more successful ones. The popularity of a measure can depend on variety of factors ranging from simplicity of the measure to politics of it.

Head count ratio (HCR), expressed as the ratio of population below poverty line to total population,[4] can be unambiguously termed as the very first and crudest measure of poverty. It treats all poor equally irrespective of whether they are a little or a lot below the poverty line. HCR is discrete in the sense that it awards a score of 1 or full poverty to anyone below certain poverty line and gives zero to anyone on or above the poverty line. In this way, HCR makes the poverty line ridiculously sacrosanct as if there is something magical about it. Five decades ago, Watts (1968, p.325) pointed out this fallacy: "*Poverty is not really a discrete condition. One does not immediately acquire or shed the afflictions we associate with the notion of poverty by crossing any particular income line. The constriction of choice becomes progressively more damaging in a continuous manner*."

Quite expectedly, put to formal test, HCR fails in continuity axiom: small changes in poor persons' income should not lead to a huge jump in the poverty level. For instance, a society with *say* 50% poor has all the poor people marginally below poverty line so that small changes in poor persons' income leaves none below the poverty line; HCR falls from 0.5 to 0. Also, since HCR does not concern the depth of poverty of the poor, it fails in monotocity axiom: decrease (increase) in poor person's income should increase (decrease) poverty. For instance, assuming a poverty line of 10 in a three-person society, income distributions (9,9,20) and (0,0,20) have same HCR values. HCR also fails transfer axioms: transfer from poor person to relatively less poor person must increase poverty. In the above-mentioned

[3] These steps are not limited to poverty measures. All indicator exercises follow these steps: (i) outlining the properties that the indicator should satisfy and (ii) examining the efficacy of the measure in terms of aforementioned properties.

[4] Poverty line is defined as the level of income below which people are diagnosed as poor (Sen, 1992)

three-person society, income distributions (5,6,20) and (2,9,20) give same HCR of 2/3. With further transfer from the poorest the HCR of resulting income distribution, *say*, (0,11,20) rather falls to 1/3.

In spite of its failure in satisfying the standard properties, HCR remains as the most widely used measure of poverty (World Bank, 2005). Sen in his 1976 seminal paper on measurement of poverty questions this anomaly. By citing several of the then works on change in India's rural poverty, Sen (1976, p220) highlights that it is difficult to reconcile 'vigorous and illuminating debate' on poverty with 'remarkable amount of sophistication' in data on one hand and use of the 'crude criterion' of HCR on the other. There are quite a few similar examples in poverty literature which have highlighted the shortcomings of HCR. However, invariably countries across the world use HCR—based on their respective national poverty line—as the main indicator to assess poverty (Sen, 1979; 1992; Zheng, 1997).[5] Internationally too, World Bank reports HCR on the basis of international poverty line.[6] The HCR is the most common tool not only for appraising poverty, but also for framing global development goals (Castleman *et al*., 2015). Not quite surprisingly, the first targets in both Millennium Development Goals and Sustainable Development Goals were set on the basis of reduction of HCR (UN, 2015; 2016).[7]

It is not that there is any dearth of poverty indicators that are superior to HCR. In one of the most comprehensive work in the poverty literature, Zheng (1997) has evaluated several classes of poverty measures against an exhaustive list of axioms. The poverty measures, which are classified as distribution sensitive and subgroup consistent,[8] satisfy almost all of the identified axioms. The theoretically superior measures are not new to the knowledge domain. These are known in the poverty discourse since last three to five decades. However,

[5] In a recent exercise by Gentilini and Sumner (2012), the authors have considered 160 countries to find global poor on the basis of national poverty lines.

[6] The international poverty line as a dollar-a-day was introduced by 1990 World Development Report, and the same has been revised thrice; and the present value is at $1.90 (at 2011 PPPs) (Ferreira, 2015).

[7] The SDGs does consider multi-dimensional poverty measure; however, this is equivalent to considering HCR in different dimensions. The targets of millennium development goal related to poverty does consider poverty gap ratio (PGR) along with HCR; however this paper ultimately argues instead of PGR, a complement indicator would have been better.

[8] The measures proposed by Watts (1968), Clark et al. (1981), Foster *et al*. (1984), and Hagenaars (1987) fall under this class of measure; these are categorized as Class 3 measure by Zheng (1997).

none of these measures could capture imagination of policy makers, media, and public at large as HCR could. In spite of its theoretical shortcomings, HCR remains as the undisputed headline indicator.

In literature the success of HCR is attributed to its simplicity, cardinal meaningfulness,[9] and suitability to the purpose of identification of poor (Atkinson, 1987; Sen, 1992; Zheng, 1997; Gibson and Olivia, 2002). Simplicity and easy interpretability are undoubtedly important attributes, but the usual tendency of scientists to substantiate the same by arguing that policymakers are not smart enough is nonetheless reasonable.[10] Identification of poor is important, but certainly not the only purpose of poverty measure. The other important purposes are: to facilitate understanding of poverty and to assess the effectiveness of the poverty eradication programmes (Zheng, 1997). HCR gives a limited understanding on poverty as it is invariant to the fall of income of poor. HCR also gives a perverse response to target the least poor for poverty reduction as more of them can be pulled out of poverty for a given transfer (Sen, 1976; Gibson and Olivia, 2002). Assuming that 'what we measure affects what we do' (Stiglitz *et al*., 2009), these limitations of HCR are serious impediments towards improving the lives of the poor.

This note suggests that part of the problem lies in the approach of 'substituting' HCR with better indicators. There has been no attempt of finding 'complementary' sets of indicators. Each time a new indicator is proposed, its goodness is evaluated against a set of axioms with the aim to substitute the existing indicators with the new one.[11] In this process, one might fail to catch the natural complementarity among the indicators. For example, income gap ratio, IGR, which is the average shortfall of the poor from poverty line, complements HCR in the sense that HCR gives 'what fraction of population is poor' while IGR gives 'how much poor the poor are'. Sen (1992, p103) did mention about this complementarity in the context of HCR and IGR: "*it is natural to think that the two must complement each other, since they address different aspects of poverty*".

[9] Cardinal concerns number, whereas ordinal concerns order or ranks.

[10] While making this point, Zheng (1997) considers policy makers to be necessarily non specialists. Gibson and Olivia (2002) go further to state "setting that needs easily interpretable measures because few policy makers have advanced education".

[11] This trend is not limited to poverty indicators, found in every other indicator exercises.

However, such complementarity is rarely explored and all researchers including Sen did not resist from the temptation of comparing the poverty measures against the same set of axioms so as to substitute the inferior measures with better ones. Therefore the conclusions drawn from such analysis are often misleading. For instance, World Bank (2002) Sourcebook on Poverty Reduction Strategies considers IGR to be 'undesirable' as it increases when a relatively less poor becomes nonpoor. It emphasizes that it is a 'problem' that IGR is defined only on the poor population (World Bank, 2002, p406).[12]

This note departs from this conventional approach. It proposes that there can be two sets of poverty measures. First, the usual measures of poverty meant for the whole population and secondly, the measures meant for only the poor. We refer to these sets of measures as 'conventional' and 'complementary' poverty measure, respectively. In Section 2, we revisit the axioms of poverty literature and propose a set of axioms that the complementary poverty measures should satisfy. Section 3 compares two measures of poverty: IGR and poverty gap ratio (PGR) and shows how PGR is a substitute to HCR, whereas IGR is a complement. Section 4 gives concluding remarks.

## 2. Axioms of a complementary poverty measure

In order to list the desirable properties of complementary poverty measure, the exhaustive list of 17 axioms (eight core axioms and nine implied axioms) considered by Zheng (1997) are revisited. We categorise these axioms into three groups: first, the axioms that required modification to suit to a complementary poverty measure; secondly, the axioms that did not require any modification other than the scope changed from entire population to only the poor; and lastly, the axioms that can be used in verbatim.

The axioms which fall in the first category are:[13] *Strong focus axiom, Restricted strong monotinicity axiom, Invertible poverty growth axiom,* and *Restricted increasing poverty line axiom*.

*Strong focus axiom*: This axiom requires a complementary poverty measure to be independent of nonpoor. The *Focus axiom* of conventional poverty measure requires the

[12] However, the same can be turned out to be an 'asset' if looked differently.

[13] These axioms have different names so as to distinguish the same from the related axioms used for conventional poverty measure.

measure to be independent of income distribution of nonpoor. However, a complementary poverty measure, i.e., meant for only the poor, is completely independent of nonpoor. It is reasonable to assume that value of such a measure of poverty should not get affected not only with the change in the income distribution of nonpoor, but also with the change in nonpoor population. In a three-person society, assuming a poverty line of 10 and income distributions (1,5,20), the value of the complementary poverty measure should not change if the income of nonpoor changes *say* to (1,5,40) or the nonpoor migrates out (1,5), or a new nonpoor joins *say* (1,5,20,25).

This axiom was first used by Subramanian (2002). The variations of this axioms are: *Poverty non-variance axiom* (Paxton, 2003), *No mere addition axiom* (Hassoun, 2009), and *Population focus axiom* (Hassoun and Subramanian, 2010). This axiom has not got due attention in literature (Subramanian, 2011).

*Restricted strong monotinicity axiom*: This axiom requires the value of a complementary poverty measure to decrease with increment in poor a person's income with the restriction that the increment does not lift the poor out of poverty. In a three-person society with a poverty line of 10, income distribution (1,5,20) should have a greater value of complementary poverty measure than that of income distribution (1,9,20).

This axiom corresponds to the *Strong monotinicity axiom* of a conventional poverty measure which does not have any such restriction. In case of complementary poverty measure, when the increment lifts the poor out of poverty, it is equivalent to poor migrating out of the society as the scope of the measure is limited only to the poor. This is the subject of the next axiom.

*Invertible poverty growth axiom*:[14] This axiom requires value of a complementary poverty measure to increase (decrease) when a poor person joins with greater (lower) poverty than the average and the value to decrease (increase) when a poor person leaves with greater (lower) poverty than the average. In a three-person society with a poverty line of 10 and income

[14] Zheng (1997) has discounted this axiom for a measure of poverty. However, we have considered a modified version of this axiom which takes into account the income level of entering or departing poor. Also, we note that we have not considered the *Non-poverty growth axiom* that implies poverty measure to increase with increase of nonpoor population. For a complementary measure of poverty, which concerns only the poor, *Non-poverty growth* axiom is out of the scope.

distribution (1,5,20), the value of complementary poverty measure should increase when the new poor joins, *say*, (1,2,5,20) and the value of complementary poverty measure should decrease when the new poor joins, *say*, (1,5,6,20). Similarly, from the same three-persons society, when a poor leaves, the initial distribution (1,5,20) should have a higher value of complementary poverty measure than that of (5,20) and lower than that of (1,20). It is worth noting here that for a complementary poverty measure, poor migrating into or out of the society is same as a nonpoor becoming poor or poor becoming nonpoor, respectively.

This axiom is a modified version of *Poverty growth axiom* as proposed by Kundu and Smith (1981) which requires the value of the conventional poverty measure to increase when a new poor person is added. *Poverty growth axiom* does not concern the exact income of the joining or departing poor.[15] Zheng (1997) argues that this axiom is not a reasonable property for measuring poverty as it is peculiar to assume poverty to increase when 'richer' poor joins a society. Quite clearly, *Poverty growth axiom* turns out to be all the more unreasonable for a complementary measure of poverty.

*Restricted increasing poverty line axiom*: This axiom requires the value of a complementary poverty measure to increase with increase in poverty line with the restriction that there is no new entrant into poverty. In a three-person society with a poverty line of 10 and income distribution (1,5,20) the value of complementary poverty measure increases when poverty line increases to *say* 15 or any value below 20.

This axiom corresponds to the *Increasing poverty line* axiom of conventional poverty measure which does not have any restriction. In case of complementary poverty measure, when increase in poverty line brings new entrants to poverty then there are two opposing effects: – (i) increase in poverty as income distribution changed with shift of poverty line, and (ii) decrease in poverty with entry of relatively 'rich' poor. The overall effect will be resultant of these two opposing effects.

[15] Kundu and Smith (1981, p430) have believed that the argument 'that "'*by adding poor persons who are 'richer' than the average poor person, the degree of poverty should thereby be decreased*' seem to ignore the *relevance of poverty line altogether*". However, this belief is premised on the notion that poverty line represents a level of deprivation below which the degree of human suffering becomes qualitatively different and hence, an increase in number of poor should increase the degree of poverty. This notion needs to be downplayed for all practical purposes as there is no such line at which one immediately acquires or sheds poverty (Watts, 1968).

Next, we list the second category of axioms: *Replication invariant axiom*, *Symmetry axiom*, *Sub-group consistency axiom* and *Decomposability axiom*. These axioms are same as the corresponding axiom of conventional poverty measure with only one difference. The scope of the axioms for the conventional poverty measure is for the entire population, whereas scope for the complementary poverty measure is limited to the poor. *Replication invariant axiom* requires a complementary poverty measure to be unchanged with replication of poor population. In the above-mentioned example, income distributions (1,5,20) and (1,1,5,5,20) give same value of complementary poverty measure. *Symmetry axiom* requires a complementary poverty measure to be such that names of the poor people do not matter. *Sub-group consistency axiom* requires a complementary poverty measure to be such that increase (decrease) in value of complementary poverty of any sub-group of poor with that of other subgroups remaining same, should increase (decrease) the overall value. *Sub-group consistency axiom* is nothing but extending the concept of monotonicity, which is concerned with change in poverty of individual, to change in poverty of subgroup. *Decomposability axiom* requires a complementary poverty measure to breakdown by own levels of complementary poverty values of subgroups. In other words *Decomposability* axiom enables to estimate the contribution of any sub-group to overall complementary poverty value. Unlike conventional poverty measure, where the contribution of the subgroup is desirable to be in proportion to its population share in total population, in case of complementary poverty, the subgroup's contribution will be desirable to be in proportion share of subgroup's poor population in total poor population.

The last category of axioms which can be used as verbatim for a complementary poverty measure are: *Continuity axiom*, *Restricted continuity axiom*, *Weak monotonicity axiom*, *Minimal transfer axiom*, *Weak transfer axiom*, *Weak transfer sensitivity axiom*, and *Normalization*. *Continuity* axiom requires the value of a complementary poverty measure to remain unchanged with a small change in a poor person's income. *Restricted continuity axiom* is restricted version of the continuity axiom, where continuity is not required on the poverty line. In other words, *Restricted continuity axiom* allows discontinuity or a jump at the poverty line. This axiom supports the view that crossover at certain income line would change the poverty level all of a sudden.[16] Watts (1968) has argued how this view has

[16] Expectedly, HCR satisfies this axiom.

unrealistic emphasis on poverty line. *Weak monotonicity axiom* requires the value of a complementary poverty measure to increase with decrease of income of poor. In a three-persons society with a poverty line of 10, income distribution (1,5,20) should have a lower value of complementary poverty measure than (1,3,20). *Minimal transfer axiom* requires the value of a complementary poverty measure to decrease (increase) with progressive (regressive) transfer among the poor, [17] with none crossing the poverty line as a result of this transfer. In the three-persons society example, between the two distributions: (1,5,20) and (2,4,20), one resulting from the other because of transfer between the two poor persons, the latter has a lower value of complementary poverty measure than the former. *Weak transfer axiom* requires the value of a complementary poverty measure to decrease (increase) with progressive (regressive) transfer with at least the recipient (donor) to be poor and none crossing the poverty line as a result of this transfer. In the three-persons society example, distributions (1,5,20) and (1,8,17), one resulting from the other because of transfer between the non-poor and the one of the poor, the latter has a lower value of complementary poverty measure than the former. *Weak transfer axiom* is a stronger form than the *Minimal transfer axiom*.[18] *Weak transfer sensitivity axiom* requires that a complementary poverty measure to be such that the transfers taking place down the distribution are given more emphasis. In the example, change in the distributions from (1,5,20) to (1,8,17) compared to change from (1,5,20) to (4,5,17) the decrease in value of complementary poverty measure is greater in the latter case. *Normalization* requires that a complementary poverty measure is bounded by 0 meaning no poverty; and unity meaning full poverty.[19]

## 3. IGR vs. PGR: Complement vs. substitute to HCR

As an illustration of conventional and complimentary measures of poverty, we consider two measures: IGR, i.e., the average shortfall of the poor from poverty line, and PGR, i.e., the average shortfall of the population from poverty line considering the nonpoor having no or

[17] A progressive transfer refers to transfer of income to a poor person from a less poor person such that the initial situation of recipient is poorer than the final situation of donor. A regressive transfer refers to transfer of income from a poor to a less poor.

[18] The other two transfer axioms in conventional poverty measure: *Progressive transfer axiom* and *Regressive transfer axiom* that are stronger in form than *Weak transfer axiom* and in which the transfer make anyone to cross poverty line are not applicable for complementary poverty measure.

[19] This axiom, as given in Zheng (1997), does not put any upper bound. However, here we have insisted an upper bound of one so as to make sense of the values.

zero shortfall. The IGR is expressed as the ratio of sum of all normalized gaps, i.e., gaps expressed as the fraction of poverty line, to the total number of poor. The PGR is as expressed as the ratio of same sum to total population.

Unlike HCR, both IGR and PGR do not treat all poor equally. Both the indicators are sensitive to depth or intensity of poverty. The farther the poor is below from the poverty line, the greater the value of IGR and PGR. If one compares both the measures as conventional measure of poverty,[20] IGR fares poorly than PGR in terms of two important axioms: *Strong monotinicity* and *Nonpoverty growth*. However, treating IGR to be a complementary poverty measure these failures act to its advantage. Let's consider the case of a relatively rich among the poor becoming nonpoor. No doubt, the overall level of poverty decreases. But with this, the average situation of poor worsens as the relatively less poor moves out. IGR captures this. Next, let's consider the case a nonpoor gets added to the population. Again with this, the poverty situation of the overall population improves. But, situation of poor remains unaffected. IGR captures the same.

However, in the absence of the notion of complementary poverty measure, the above mentioned abilities of IGR to reflect the state of poor go unseen. Rather failure in satisfying *Strong monotinicity* and *Nonpoverty growth* are draws criticism in the poverty literature, so much so that World Bank (2002, p406) settles that "*It must be emphasized that the income gap ratio in itself is not a good measure of poverty*".

The failure of IGR is misplaced as it is misconstrued as measure of poverty for the entire population. Rather, it indicates the poverty of the poor. It is a natural complement to HCR. It is PGR, which is a natural substitute of HCR. PGR improves over HCR by giving weights to each poor person in accordance to the distance from the poverty line. In this sense, PGR is a refined version of HCR. Further, it can be refined to be distribution sensitive if one considers square of poverty gap ratio (SPGR). SPGR takes the square of the shortfall from the poverty line thereby gives greater weight to the poor person who is farther from the poverty line. SPGR satisfies all the eight core axioms listed in Zheng (1997). Also, it is interesting to note that SPGR values are bounded by PGR values, which in turn are bounded by HCR values indicating progressive refinement. That makes PGR and SPGR as substitutes for HCR.

[20] For comparison of different measures of poverty against axioms please refer to Table 3.1 in Zheng (1997)

However, IGR is a complementary poverty measure. HCR gives 'what fraction of population is poor' while IGR gives 'how much poor the poor are'. Among the axioms listed for complementary poverty measure in this note, IGR satisfies *strong focus axiom, restricted strong monotinicity axiom, reversible poverty growth axiom, restricted increasing poverty line axiom, replication invariant axiom, symmetry axiom, sub-group consistency axiom, decomposability axiom, restricted continuity axiom,*[21] and *normalization*. It fails in the distribution sensitive axioms such as: *weak monotonicity axiom, minimal transfer axiom, weak transfer axiom,* and *weak transfer sensitivity axiom*. If one considers square of income gap ratio (SIGR), which squares the shortfall from the poverty line, it would satisfy those axioms well. So, in this sense SIGR is a substitute indicator to IGR, but both of these measures are complements to HCR.

Table 1

| **Country** | **HCR** | **PGR** | **IGR** |
|---|---|---|---|
| India | 21.25 | 4.27 | 20.10 |
| Chile | 1.30 | 0.50 | 38.46 |
| South Africa | 16.56 | 4.90 | 29.59 |
| Lithuania | 0.87 | 0.82 | 94.25 |

Let us consider HCR, IGR, and PGR for some countries (Table 1). Consider the comparison between India and Chile. India has 21.25% people poor whereas the corresponding figure for Chile is 1.30%. However, the IGR values show that on an average the Chilean poor is poorer than the Indian poor. This is not apparent in PGR values, as the same is bounded by HCR. One can find similar observation comparing Lithuania and South Africa.

## 4. Concluding remarks

One of the failures of poverty research so far has been that none of the measures, which are more advanced than the crude measure of HCR, could get as much limelight, if not more, in policy and public discourse as HCR could get. We argue that the problem lies with the conventional approach of substituting HCR with a better indicator while ignoring their complementarities. This note proposes two sets of poverty measures—one for the population

[21] IGR fails in continuity axiom as it takes the value 0/0 when all the poor move to poverty line.

(conventional poverty measure), and one for the poor (complementary poverty measure). It outlines the desirable properties of a complementary poverty measure.

The note illustrates the central idea by considering two indicators: IGR and PGR. The IGR that gives the average depth of poverty of the poor naturally complements the HCR, but does not fair as a good indicator under the conventional approach. The IGR exposes the state of the poor unlike the PGR that dilutes the average depth of poverty by including nonpoor. The PGR, which refines the value of HCR, turns out to be one of its substitutes. Evidently, the PGR is bounded by HCR values, whereas IGR does not suffer from that restriction.

There has been a failure to recognize this important differentiation. In the report by World Bank (2017) on Monitoring Global Poverty, the Commission on Global Poverty wrongly recommends PGR as complementary indicator to HCR. This note demonstrates that IGR is a better choice for complementing HCR as the poverty of the poor does not hide behind the large number of nonpoor. Hence, putting it alongside HCR will give state of the poor, i.e., how poor the poor are, and thereby incentivising the attack on poverty.

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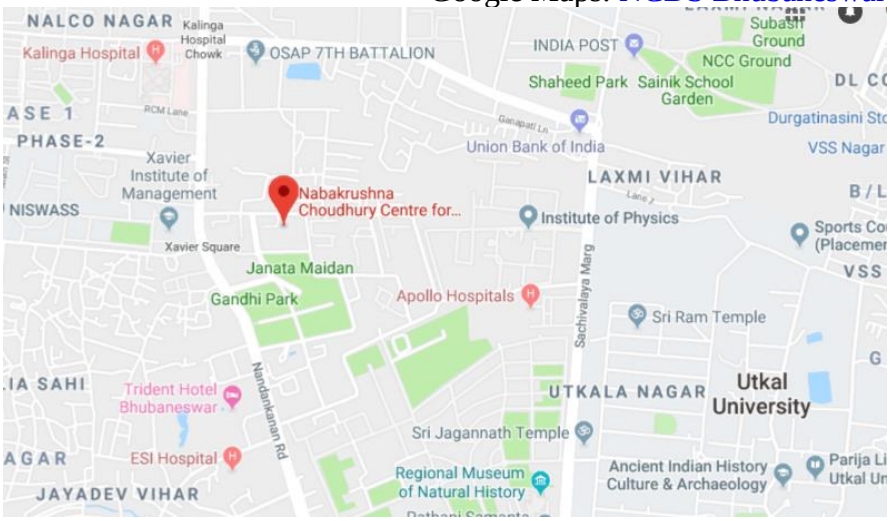


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