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Abstract

We present a microeconomic analysis of subsistence in the consumer theory framework with two goods: the basic good (food) and the non-basic good (non-food). Subsistence results in two regions in the consumption set: the pre subsistence zone in which the individual's subsistence requirement is not met and he exclusively cares about the basic good, and the post subsistence zone. This structure gives subsistence induced (SI) preferences. Compared to Stone-Geary utility functions, SI preferences give a better understanding of consumption decision problems for people who are on the margins of subsistence and can be useful to clarify related issues such as the use of child labor for poor households.

Keywords: subsistence; pre subsistence zone; post subsistence zone; SI preferences
JEL Classification: D01, D11, O12

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> 'Of the nonpossession of the matter of subsistence in such quantity as is necessary to the support of life, death is the consequence: and such natural death is preceded by a course of suffering much greater than what is attendant on the most afflictive violent deaths employed for the purpose of punishment.'
> —Jeremy Bentham, *Pannomial Fragments* (1843).

1 Introduction

Subsistence is the minimum amount of basic necessities essential for survival. Food is the most basic necessity. According to the latest estimates of the United Nations (2021), about 768 million people globally faced severe food insecurity in 2020. This means nearly one in ten people in the world do not get enough food to eat. In view of the grave challenges posed by hunger and undernourishment, the concept of subsistence as a minimum critical level remains useful for policymakers. An important example of this is the *Minimum Dietary Energy Requirement* (MDER), which is a population-specific cutoff for food adequacy used by the Food and Agriculture Organization of the United Nations (FAO) to measure the prevalence of undernourishment. Using the MDER, an individual is considered to be undernourished in FAO estimates if his dietary intakes fall short of this minimum requirement.[1]

The existence of a large number of undernourished people in the world brings out one key point: an undernourished person does not instantaneously drops dead. Long term state of undernourishment of course lowers the longevity of life, but living years do continue accompanied by miseries such as more vulnerability from diseases, stress, weakness and lower mental ability—'a course of suffering' alluded to by Bentham (1843). The fact that undernourishment does not imply instantaneous death is well recognized. For instance, Dasgupta (2004) states:

> 'Modern nutrition science has shown that relatively low mortality rates can coexist with a high incidence of undernutrition and morbidity. To be sure, many die, owing to causes traceable directly to their poverty. But large numbers continue to live under nutritional and environmental stress.'

A second point to note is that although undernourishment and poverty are different concepts (one refers to low nutrition while the other to low income), they are closely related. An individual is undernourished because most likely he does not have enough income to afford the minimum required food. The World Bank (2022) currently sets the international poverty line at a daily income of $2.15 (in 2017 purchasing power parity US dollars). In spite of the methodological debates that surround such cutoffs, it is perhaps safe to conclude that a large number of people with a daily income below $2.15 are also undernourished.

[1]The methodology of assessing the prevalence of undernourishment has been revised by the FAO over the years (see, e.g., FAO, 2014; Wanner et al., 2014). A large literature has looked at measurement issues of assessing undernutrition and has often critically examined the FAO indicators of undernourishment. See, e.g., Sukhatme (1961, 1978), Srinivasan (1981), Kakwani (1989), Naiken (1998), Svedberg (2002) and de Haen et al. (2011).

Given this background, we seek to present a microeconomic analysis of subsistence in the standard consumer theory framework. This paper is premised on three observations: (i) any individual requires a certain minimum level of nutrition; this is what we call the individual's subsistence requirement, (ii) if this requirement is not met, the individual suffers but does not instantaneously die and (iii) the main reason why an individual fails to attain his subsistence requirement is because he is poor. To place this individual problem in the consumer theory framework, we have to specify (a) the individual's preference and (b) his income. The third observation above has to do with an individual's income. Let us look at the first two for describing his preference.

Consider an individual who has not attained his subsistence requirement and is still alive. We posit that in this situation, nourishment must be his exclusive concern.[2] Consequently, the individual only finds those goods useful that contribute to nutrition; goods that do not contribute to nutrition are not useful at all. In a two-good setting in which the basic good (food) contributes to nutrition and the non-basic good (non-food) does not, this implies that when the quantity of food is lower than what is needed to meet his subsistence requirement, the individual exclusively cares about food and finds the non-food good useless. On the other hand, if an individual has attained his subsistence requirement, nourishment is no longer his exclusive concern and both kinds of goods can be useful.

This leads to our defining structure that incorporates subsistence in the consumption decision problem. An individual's consumption set has two regions: the *pre subsistence zone* in which the individual's subsistence requirement is not met and he exclusively cares about the basic good, and the *post subsistence zone* in which his subsistence requirement is met and both goods can be useful. The subsistence requirement gives *subsistence induced* (SI) preferences (Definition 2). A wide range of consumption behavior (for instance, different forms of imperfect substitution between goods) can be supported in the post subsistence zone. It is worthwhile to include another aspect of the basic good in this set-up. This is saturation: once an individual has consumed the basic good in sufficient amount, more of it is not beneficial. The subsistence requirement, together with saturation of the basic good, gives *subsistence and saturation induced* (SSI) preferences (Definition 3), which is a subclass of SI preferences.

The key concept of our analysis is the *irrelevance* of a good in a consumption bundle. Consider an individual consumption decision problem with two goods: the basic good (food) and the non-basic good (non-food). The preference of the individual is assumed to be monotone and continuous.[3] We say a good is irrelevant at a consumption bundle if increasing its amount without changing the amount of the other good keeps the

[2]This is how Maslow (1943) articulates the condition of a person whose physiological need for food is not met: 'All capacities are put into the service of hunger-satisfaction...Capacities that are not useful for this purpose lie dormant, or are pushed into the background. The urge to write poetry, the desire to acquire an automobile, the interest in American history, the desire for a new pair of shoes are...forgotten or become of secondary importance. For the man who is extremely and dangerously hungry, no other interests exist but food.'

[3]The continuous preference setting helps us to better integrate the post subsistence zone of SI preferences with other standard preferences. Also, effects of changes in incomes for individuals on the margins of subsistence can be more clearly understood with continuous preferences (see Sections 4.1,4.4).

consumer indifferent (Section 2.1). For SI preferences, the non-basic good is irrelevant in the pre subsistence zone. For SSI preferences, in addition, the basic good becomes irrelevant when its saturation is reached.

Observe that the structure of pre and post subsistence zones is about an individual's preference, not his income. What is then the role of income? Given this structure (which reflects individual preference) and prices of the goods, it is income that determines the consumption choices an individual will make. If an individual's income is so low that he cannot afford to get the amount of food needed to meet his subsistence requirement, he will end up in the pre subsistence zone. Such an individual will use his insufficient income to get the amount that brings him as close as possible to the subsistence level. On the other hand, an individual with sufficiently high income will end up in the post subsistence zone. In short, the subsistence requirement is universal, it applies to all individuals regardless of income. What income determines is whether an individual will succeed or fail to attain his subsistence requirement. This is how undernourishment is linked with poverty.

The causal link between undernourishment and poverty can be in the other direction in that undernourishment can perpetuate poverty. A dominant channel through which this happens is what Dasgupta (2004) calls 'metabolic pathways' that are '... based on physiological links connecting nutritional status and work capacity...'. Studies following this line of inquiry include Ray and Dasgupta (1986), who argue that food inadequacy of an individual makes his labor less productive and leads to lower income. In a similar vein, Sharif (2003) argues that the need for physical rest is accentuated for a worker who has a low food intake, making it dfficult to increase his working hours. In this paper we do not attempt to endogenize income. Given an individual's income, our objective is to understand consumption behavior in the presence of subsistence.

The modeling of subsistence in the consumer theory framework has not been very satisfactory. This was pointed out long back by Stigler (1950),[4] but the lacuna still remains. Stone-Geary utility functions are widely used to model subsistence (see, e.g., Steger, 2000; Ravn et al., 2008). Under these functions it is implicitly assumed that an individual always has enough income to afford at least the amount of good that corresponds to the subsistence level. What happens if the individual cannot afford this minimum amount? Presumably he immediately dies, so there is no decision problem of interest. As we have seen, failure to meet the subsistence requirement does not imply immediate death. Thus, the modeling of subsistence in the Stone-Geary formulation is not very rigorous and as a result it essentially ignores the problem of the poor. By contrast, the structure of pre and post subsistence zones of SI preferences is attentive to the consumption decision problem at low levels of income.

The Stone-Geary formulation is also inadequate to see the implications of a negative income shock for people who are on the margins of subsistence. For example, consider a daily wage worker who earns an income just high enough to keep him marginally above the subsistence. An external shock such as an extended lockdown in response

[4]According to Stigler (1950): 'Occasionally it was stated that the marginal utility of a necessity falls rapidly as its quantity increases and the like; and there were some mystical references to the infinite utility of subsistence. These were *ad hoc* remarks, however, and were not explicitly developed parts of the formal theory.'

to a pandemic can lower his income to take him from post to pre subsistence zone.[5] SI preferences are better equipped to understand such situations (see Section 4.1).

Our analysis of subsistence consumption gives a better understanding of the use of child labor for households whose income without child labor is only marginally above the minimum income needed to meet the subsistence requirement (see Section 4.4). In the well known child labor model of Basu and Van (1998), it is assumed that such marginal households completely stop using any child labor. By contrast, our analysis shows that depending on the preference of the household (specifically, the nature of substitution between the basic good and the non-working time of the child), it is possible that certain marginal households may continue to use child labor.

A related literature has looked at the nature of substitution across different food items at low levels of income to address issues such as minimum cost diet (e.g., Stigler, 1945; Sharif, 1986) and Giffen behavior (Jensen and Miller, 2008). Our main framework does not directly address these issues as it has only one food item in the form of the basic good. However, as we show in Example 3, they can be accommodated in an extended framework with multiple basic goods.

We present the analytical framework in Section 2, introducing the concept of irrelevance in Section 2.1. SI preferences are defined in Section 3, together with examples. Specific aspects of SI preferences are discussed in Section 4. In conclusion, we comment on issues such as multiple basic goods and expanded set of basic needs in Section 5.

2 The analytical framework

Drawing on Lectures 1,2 of Rubinstein (2012), we begin by presenting some key concepts and definitions of the individual consumption decision problem.

Consider the problem of an individual consumer in a two-good setting where the set of goods is $\{1, 2\}$. We consider good 1 to be the basic good (food) and good 2 the non-basic good (non-food). The individual has a consumption set $X = X_1 \times X_2$ where $X_i = \mathbb{R}_+$ for $i \in \{1, 2\}$ and $X = \mathbb{R}^2_+$. A consumption bundle is $x = (x_1, x_2) \in X$ where x_i stands for the quantity of good i. Generic points in X are denoted by x, y, z.

For $x_i \in X_i$, we say a *consumption bundle involves* x_i if the quantity of good i in that bundle is x_i. For instance, $(x_1, 0)$, $(x_1, 4)$, are some bundles that involve x_1 while $(0, x_2)$, $(7, x_2)$, are some bundles that involve x_2.

The individual's preference on X is defined using the binary relation $\succsim$ where "$x \succsim y$" stands for "the individual prefers x to y". The strict preference "$x \succ y$" stands for "the individual strictly prefers x to y" and is defined as $x \succ y \Leftrightarrow [x \succsim y]$ and [not $y \succsim x$]. The indifference relation "$x \sim y$" stands for "the individual is indifferent between x and y" and is defined as $x \sim y \Leftrightarrow [x \succsim y]$ and $[y \succsim x]$.

For any $x \in X$, the indifference set is $I(x) = \{y \in X \mid x \sim y\}$. Taking the quantity of good 1 on the horizontal and good 2 on the vertical axis, for any $x \in X = \mathbb{R}^2_+$, the *indifference curve containing the bundle* x is the set $I(x)$.

[5] See, e.g., ILO (2020) and Laborde et al. (2020) for an overview of the consequences of the corona pandemic on labor earnings and employment globally. For this problem in the specific context of migrant workers in India, see, e.g., Adhikari et al. (2020), Drèze (2020) and Mander et al. (2020).

A preference relation $\succsim$ on X is *complete* if for any $x, y \in X$, either $x \succsim y$ or $y \succsim x$ or both. It is *transitive* if: for any $x, y, z \in X$, if $x \succsim y$ and $y \succsim z$, then $x \succsim z$.

Let $x, y \in X$. If $x_i > y_i$ for all i, we write $x > y$. If $x_i \geq y_i$ for all i, we write $x \geq y$. A preference relation $\succsim$ on X is *monotone* if for any $x, y \in X$ we have $x \succsim y$ if $x \geq y$ and $x \succ y$ if $x > y$. It is *strong monotone* if for any $x, y \in X$ with $x \geq y$ and $x \neq y$, we have $x \succ y$.

The distance between $x, y \in X$, denoted by $d(x, y)$, is given by the Euclidean metric. A neighborhood of x is a set $N_\varepsilon(x)$ consisting of all $y \in X$ such that $d(x, y) < \varepsilon$ for some $\varepsilon > 0$.

A preference relation $\succsim$ is *continuous* on X if for any $x, y \in X$ with $x \succ y$, there exists $\varepsilon > 0$ such that if $\widetilde{x} \in N_\varepsilon(x)$ and $\widetilde{y} \in N_\varepsilon(y)$, then $\widetilde{x} \succ \widetilde{y}$. Thus for a continuous preference, strict preference order between any two consumption bundles is preserved around their small neighborhoods.

A function $u : X \to \mathbb{R}$ *represents* $\succsim$ if for all $x, y \in X$, $x \succsim y$ if and only if $u(x) \geq u(y)$. If u represents the preference relation $\succsim$, we say u is a *utility function* representing $\succsim$. The following result will be useful. For the proof, see, e.g., Rubinstein (2012, p.18).

Result *If $\succsim$ is a complete, transitive and continuous preference relation on $X = \mathbb{R}^2_+$, then there is a continuous utility function $u : X \to \mathbb{R}$ that represents $\succsim$.*

Throughout we consider preference relations on X that are complete, transitive, monotone and continuous.

2.1 Irrelevance of a good at a consumption bundle

Two features of the basic good (food) will be useful for our analysis. The first is the subsistence requirement: the individual requires a minimum critical level of the basic good. When this requirement is not met, the individual's exclusive consideration is to have the basic good; the non-basic good (non-food) is not useful in such a situation. The second feature of the basic good is saturation. Beyond a point, consuming more of the basic good is not useful. The common aspect of these two features is 'irrelevance' of one of the two goods.

Definition 1 For a consumption bundle $x = (x_1, x_2)$, we say good 2 is *irrelevant at x* if $x \sim (x_1, y_2)$ for all $y_2 > x_2$. Similarly good 1 is *irrelevant at x* if $x \sim (y_1, x_2)$ for all $y_1 > x_1$.

For a monotone preference relation, $(x_1, y_2) \succsim x$ for all $y_2 > x_2$ and $(y_1, x_2) \succsim x$ for all $y_1 > x_1$. That is, increasing the quantity of one good without changing the quantity of the other good does not make the individual worse off. A good is irrelevant at a consumption bundle if increasing its quantity (no matter by how much it is increased) without changing the quantity of the other good does not make the individual better off either. In other words, irrelevance of a good at a bundle means raising the consumption of only that good brings no additional benefit to the individual.

A good is *relevant* at a bundle x if it is not irrelevant there. Thus good 2 is relevant at x if there is some $y_2 > x_2$ such that $(x_1, y_2) \succ x$. Similarly good 1 is relevant at x if there is some $y_1 > x_1$ such that $(y_1, x_2) \succ x$.

To see how irrelevance of a good is reflected in indifference curves, take the quantity of good 1 on the horizontal and good 2 on the vertical axis. If good 2 is irrelevant at a bundle x, for all $y_2 > x_2$ the bundle (x_1, y_2) lies on the same indifference curve that contains x. So the part of the indifference curve that contains any such bundle is a vertical straight line. Figure 1(a) gives an example of an indifference curve containing a bundle x at which good 2 is irrelevant.

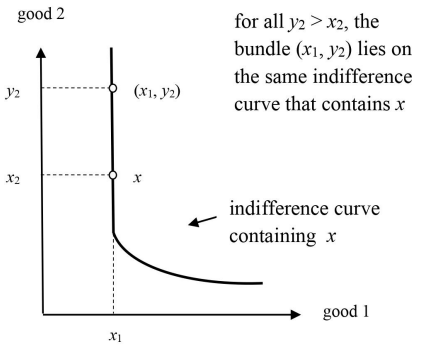

Figure 1(a): good 2 irrelevant at x

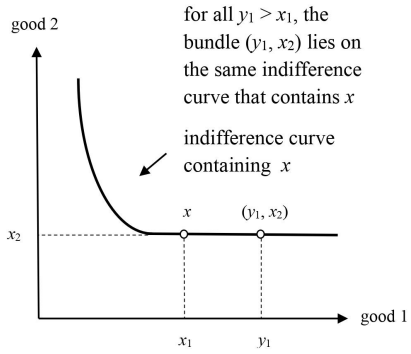

Figure 1(b): good 1 irrelevant at x

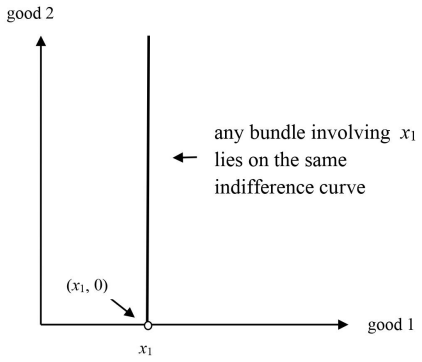

Figure 1(c): the individual exclusively values good 1 at x_1 (good 2 irrelevant at all bundles involving x_1)

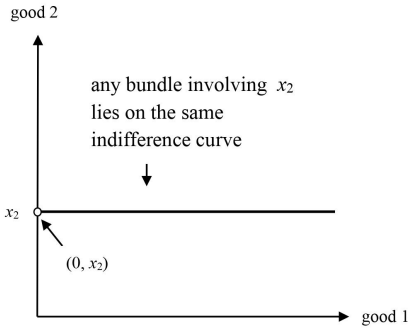

Figure 1(d): the individual exclusively values good 2 at x_2 (good 1 irrelevant at all bundles involving x_2)

Similarly if good 1 is irrelevant at a bundle x, for all $y_1 > x_1$ the bundle (y_1, x_2) lies on the same indifference curve that contains x. Thus, the part of the indifference

curve that contains any such bundle is a horizontal straight line. Figure 1(b) gives an example of an indifference curve containing a bundle x at which good 1 is irrelevant.

The following observation summarizes some implications of irrelevance. Some of these are immediate, for others we use continuity of the preference relation.

Observation 1 *The following hold for any consumption bundle $x = (x_1, x_2) \in X$.*

(i) (a) *Good 1 is irrelevant at x if and only if it is irrelevant at (y_1, x_2) for all $y_1 > x_1$.*

(b) *If good 1 is irrelevant at (x_1, y_2) for all $0 \leq y_2 < x_2$, then it is irrelevant at x.*

(c) *If good 1 is relevant at x, then it is relevant at (y_1, x_2) for all $y_1 < x_1$.*

(d) *If good 1 is irrelevant at x, then there exists $g(x_2) \geq 0$ such that at (y_1, x_2), good 1 is irrelevant if $y_1 \geq g(x_2)$ and relevant if $y_1 < g(x_2)$.*

(ii) (a) *Good 2 is irrelevant at x if and only if it is irrelevant at (x_1, y_2) for all $y_2 > x_2$.*

(b) *If good 2 is irrelevant at (y_1, x_2) for all $0 \leq y_1 < x_1$, then it is irrelevant at x.*

(c) *If good 2 is relevant at x, then it is relevant at (x_1, y_2) for all $y_2 < x_2$.*

(d) *If good 2 is irrelevant at x, then there exists $h(x_1) \geq 0$ such that at (x_1, y_2), good 2 is irrelevant if $y_2 \geq h(x_1)$ and relevant if $y_2 < h(x_1)$.*

Proof See the Appendix. ■

2.2 Exclusively valuing a good

Using irrelevance, now we describe a situation in which the individual exclusively values a certain good, so the other good is not beneficial at all. For $x_i \in X_i$, we say the individual *exclusively values good i at x_i* if the other good j is irrelevant at all bundles involving x_i. In that case when the quantity of good i is x_i, consumption of good j is not beneficial at all.

To see this in terms of indifference curves, first consider $x_1 \in X_1$ and suppose the individual exclusively values good 1 at x_1. Then good 2 is irrelevant at all bundles involving x_1, so in particular good 2 is irrelevant at the bundle $(x_1, 0)$. Thus $(x_1, 0) \sim (x_1, y_2)$ for all $y_2 > 0$. This means the indifference curve containing $(x_1, 0)$ is a vertical straight line that contains all bundles involving x_1. This is illustrated in Figure 1(c). In terms of Observation 1(ii)(d), this is a situation in which $h(x_1) = 0$.

Similarly for $x_2 \in X_2$, if the individual exclusively values good 2 at x_2, good 1 is irrelevant at all bundles involving x_2 and the indifference curve containing $(0, x_2)$ is a horizontal straight line that contains all bundles involving x_2. This is illustrated in Figure 1(d). In terms of Observation 1(i)(d), this is a situation in which $g(x_2) = 0$.

3 Subsistence induced preferences

Definition 2 Consider a preference relation $\succsim$ on $X = \mathbb{R}^2_+$ which is complete, transitive, monotone and continuous. We say $\succsim$ is *subsistence induced* (*or SI*) *preference* if $\exists\ \underline{Q} > 0$ (called the *subsistence threshold*) such that

(a) the individual exclusively values good 1 at every $x_1 \leq \underline{Q}$ (we say $[0, \underline{Q}]$ is the *pre subsistence zone*).

(b) the individual does not exclusively value good 1 at any $x_1 > \underline{Q}$ (we say $(\underline{Q}, \infty)$ is the *post subsistence zone*).

As mentioned, good 1 is the basic good (food) and good 2 is the non-basic good (non-food). The subsistence threshold $\underline{Q}$ is the quantity of food that corresponds to the minimum required level of nutrition for the individual. When $x_1 < \underline{Q}$, the individual does not attain his subsistence requirement; in that case his exclusive concern is nutrition, so he exclusively cares about food and finds the non-food good useless.[6] Thus for any such x_1 we have a situation as in Figure 1(c): the indifference curve containing $(x_1, 0)$ is a vertical straight line that contains all bundles involving x_1.

Consider $x_1, y_1 \in [0, \underline{Q}]$ such that $y_1 > x_1$. Take any y_2, x_2 with $y_2 > x_2$. By monotonicity, $(y_1, y_2) \succ (x_1, x_2)$. Since $(y_1, 0) \sim (y_1, y_2)$ and $(x_1, 0) \sim (x_1, x_2)$, by transitivity we have $(y_1, 0) \succ (x_1, 0)$. So the individual prefers any bundle involving y_1 over any bundle involving x_1. As shown in Figure 2(a), this means in the pre subsistence zone $[0, \underline{Q}]$, all indifference curves are parallel vertical straight lines, each meeting the horizontal axis. Thus in the pre subsistence zone: (i) for any two bundles with different quantities of good 1, the individual prefers the one that has a higher quantity of good 1 and (ii) the individual is indifferent between any two bundles that have the same quantity of good 1.[7]

The individual exclusively values good 1 for any x_1 in the pre subsistence zone. The negation of this is what property (b) requires for any x_1 in the post subsistence zone: for any such x_1, the individual *does not* exclusively value good 1, meaning good 2 is relevant at some bundle involving any such x_1. This implies that for every $x_1 > \underline{Q}$ in the post subsistence zone, there is some $x_2 > 0$ such that $(x_1, x_2) \succ (x_1, 0)$ (see Figure 2(b)).

Example 1 Let $0 < \underline{Q} < \infty$, $0 < \alpha < 1$. Let $x = (x_1, x_2) \in \mathbb{R}^2_+$ and $u : \mathbb{R}^2_+ \to \mathbb{R}$ be a utility function representing a preference on $X = \mathbb{R}^2_+$. given by

$$u(x) = \begin{cases} x_1 & \text{if } 0 \leq x_1 \leq \underline{Q}, \\ \underline{Q} + \left(x_1 - \underline{Q}\right)^{\alpha} x_2^{1-\alpha} & \text{if } x_1 > \underline{Q}. \end{cases} \tag{1}$$

This utility function represents an SI preference with subsistence threshold $\underline{Q}$. For any $x_1 > \underline{Q}$, $u(x_1, x_2)$ is increasing in x_2, so property (b) of Definition 2 holds. Some indifference curves of this preference are drawn in Figure 3.

[6] As the individual exclusively values good 1 for all $x_1 < \underline{Q}$, by continuity the same thing happens also at $x_1 = \underline{Q}$ (see Observation 1(ii)(b)). This is why for clarity of presentation, we include $x_1 = \underline{Q}$ in the pre subsistence zone.

[7] Note that for a lexicographic preference, (i) holds but (ii) does not.

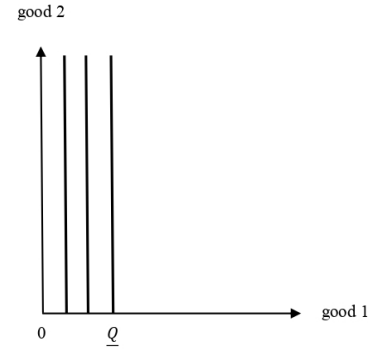

Figure 2(a): pre subsistence zone

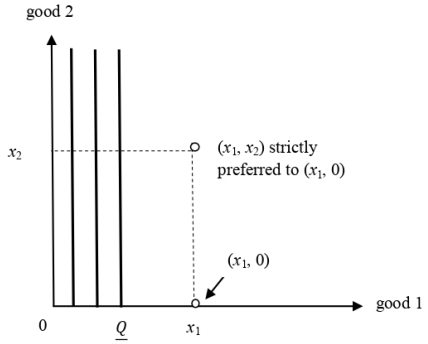

Figure 2(b): x_1 in post subsistence zone

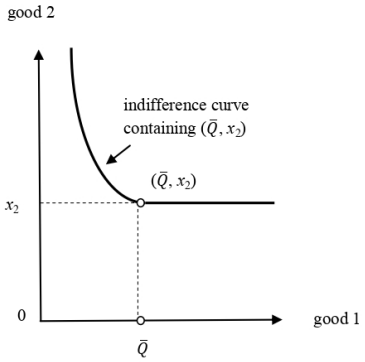

Figure 2(c): saturation threshold $\bar{Q}$

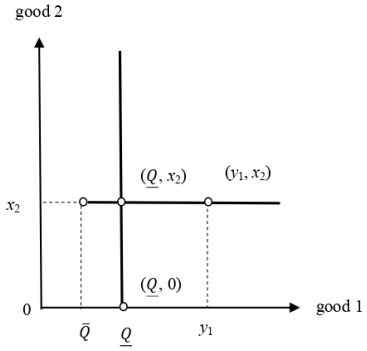

Figure 2(d): If $\bar{Q} \leq \underline{Q}$, then monotonicity is violated

3.1 Subsistence and saturation induced preferences

While the basic good such as food has its exclusive use in meeting the subsistence requirement, at the other extreme, once an individual has consumed sufficiently large amounts of the basic good, consuming more of it may not be useful. Incorporating this feature gives us the following subclass of SI preferences.

Definition 3 Consider a preference relation $\succsim$ on $X = \mathbb{R}^2_+$ which is complete, transitive, monotone and continuous. We say that $\succsim$ is *subsistence and saturation induced*

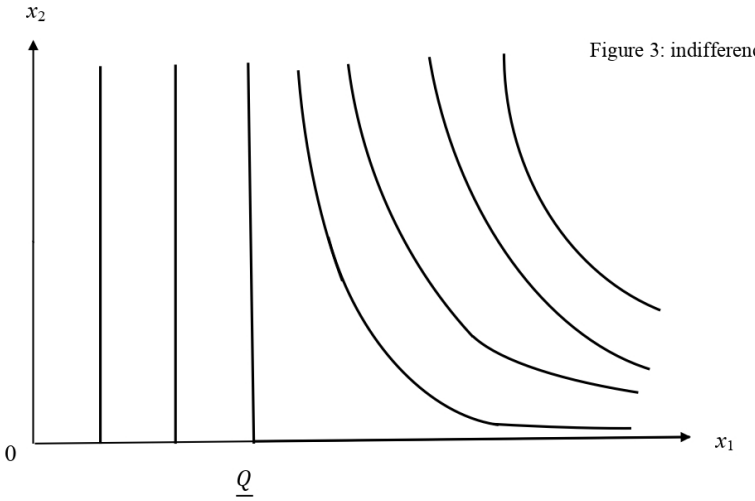

Figure 3: indifference curves for Example 1

(or SSI) preference if $\exists\ \underline{Q} > 0$ (called the *subsistence threshold*) and $\overline{Q} > 0$ (called the *saturation threshold*) such that

(a) the individual exclusively values good 1 at every $x_1 \leq \underline{Q}$ (we say $[0, \underline{Q}]$ is the *pre subsistence zone*).

(b) the individual does not exclusively value good 1 at any $x_1 > \underline{Q}$ (we say $(\underline{Q}, \infty)$ is the *post subsistence zone*).

(c) *saturation*: for any $x = (x_1, x_2)$, good 1 is irrelevant at x if $x_1 \geq \overline{Q}$ and relevant at x if $x_1 < \overline{Q}$.

Property (c) says that at a consumption bundle involving any $x_2 \in X_2$, whenever the quantity of good 1 is at least $\overline{Q}$, raising the consumption of good 1 is not beneficial for the individual. The threshold $\overline{Q}$ represents the saturation level of good 1. For all $x_1 > \overline{Q}$, the bundle (x_1, x_2) lies on the same indifference curve that contains $(\overline{Q}(x_2), x_2)$. So the part of the indifference curve that contains any such bundle is a horizontal straight line (see Figure 2(c)). The next observation shows that for SSI preferences, there is a natural order between the subsistence threshold $\underline{Q}$ and the saturation threshold $\overline{Q}$.

Observation 2 *For an SSI preference:* (i) $\underline{Q} < \overline{Q}$ *and* (ii) *for any* x_2, *the indifference curve containing* $(\overline{Q}, x_2)$ *does not contain any bundle* (x_1, x_2) *for which* $x_1 < \overline{Q}$.

Proof See the Appendix. ■

Example 2 Let $0 < \underline{Q} < \overline{Q} < \infty$ and

$$u(x) = \begin{cases} x_1 & \text{if } 0 \leq x_1 \leq \underline{Q}, \\ x_1 + (x_1 - \underline{Q})x_2 & \text{if } \underline{Q} < x_1 < \overline{Q}, \\ \overline{Q} + (\overline{Q} - \underline{Q})x_2 & \text{if } x_1 \geq \overline{Q}. \end{cases} \tag{2}$$

This utility function represents an SSI preference with subsistence threshold $\underline{Q}$ and saturation threshold $\overline{Q}$. Note that for any $x_1 > \underline{Q}$, $u(x_1, x_2)$ is increasing in x_2, which shows that property (b) of Definitions 2,3 holds. Some indifference curves of this preference are drawn in Figure 4.

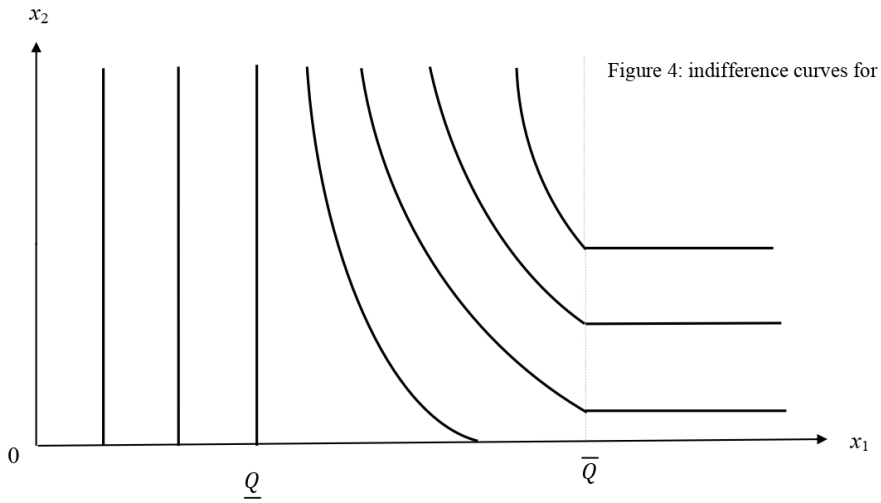

Figure 4: indifference curves for Example 2

4 Specific aspects of SI preferences

Using the examples of the last section, let us now look at certain specific aspects of SI preferences. For this discussion it will be useful to describe the utility maximization problem. Consider an individual consumer whose preference relation on $\mathbb{R}^2_+$ is represented by a utility function $u : \mathbb{R}^2_+ \to \mathbb{R}$. The prices of goods $1, 2$ are $p_1, p_2 > 0$ and the income of the consumer is $w > 0$, so the utility maximization problem is

$$\text{choose } x \in \mathbb{R}^2_+ \text{ to maximize } u(x) \text{ subject to } p_1 x_1 + p_2 x_2 \leq w \tag{3}$$

4.1 SI preferences and Stone-Geary utility functions

Stony-Geary utility functions are widely used to model subsistence. Using Example 1 we show how SI preferences capture certain implications of subsistence that are ignored by Stone-Geary utility functions.

Denote $\underline{w}(p_1) = p_1\underline{Q}$. For the utility function $u(x)$ given in (1), the unique solution $x^* = (x_1^*, x_2^*)$ to the utility maximization problem (3) is

$$x^* = \begin{cases} \left(\frac{w}{p_1}, 0\right) & \text{if } w \leq \underline{w}(p_1), \\ \left(\underline{Q} + \frac{\alpha(w-\underline{w}(p_1))}{p_1}, \frac{(1-\alpha)(w-\underline{w}(p_1))}{p_2}\right) & \text{if } w > \underline{w}(p_1). \end{cases} \tag{4}$$

Note that for $x_1 > \underline{Q}$ in (1), $u(x)$ resembles a Stone-Geary function,[8] but there is a qualitative difference. To attain the subsistence requirement, the individual needs the minimum income $\underline{w}(p_1) = p_1\underline{Q}$. This intrinsic aspect of subsistence is missing from Stone-Geary utility functions as there it is implicitly assumed that any consumer *always* has enough income to stay in the post subsistence zone.

The Stone-Geary formulation has two limitations. First, it ignores the problem of an individual whose income is below $\underline{w}(p_1)$. Second, it is also inadequate for the problem of an individual whose income is marginally above $\underline{w}(p_1)$. Suppose there is an increase in the price of the basic good or there is an external shock such as a lockdown of workplaces due to a pandemic that lowers the income. In such cases an individual with an income only marginally above the minimum level may see his income fall below that level and as a result he may slip from post to pre subsistence zone. On the other hand, an individual whose income was already insufficient will suffer a further loss of consumption in the pre subsistence zone. These issues are better addressed by the framework of SI preferences.

4.2 SI and quasilinear preferences

Under SI preferences the individual exclusively values good 1 whenever the consumption of good 1 does not exceed $\underline{Q}$. As a result, as shown in (4), if p_1, w are such that it is not feasible to buy more than $\underline{Q}$ units of good 1 (that is, $w \leq \underline{w}(p_1) = p_1\underline{Q}$), the optimal consumption choice involves not buying good 2 at all. A key point to observe here is that the price of good 2 has no role in such a choice. When $w \leq \underline{w}(p_1)$, it is optimal not to buy good 2 even if p_2 is extremely low.

Like SI, under a quasilinear preference it is possible to have situations in which the optimal consumption choice involves not buying a certain good. However, in contrast to SI, the price of that good is always a determining factor in such a choice. To see this, consider the utility function $u : \mathbb{R}^2_+ \to \mathbb{R}$ given by

$$u(x) = \sqrt{x_1} + x_2 \tag{5}$$

[8] A Stone-Geary utility function is of the form $v(x) = (x_1 - \underline{x}_1)^k(x_2 - \underline{x}_2)^{1-k}$ where $\underline{x}_i$ is the subsistence level for good i. Taking $\underline{x}_1 = \underline{Q}$ and $\underline{x}_2 = 0$ gives us $v(x) = (x_1 - \underline{Q})^k x_2^{1-k}$.

that represents a quasilinear preference. For this preference, the unique solution $x^* = (x_1^*, x_2^*)$ to the utility maximization problem (3) is

$$x^* = \begin{cases} \left(\frac{w}{p_1}, 0\right) & \text{if } w \leq \frac{p_2^2}{4p_1}, \\ \left(\frac{p_2^2}{4p_1^2}, \frac{w}{p_2} - \frac{p_2}{4p_1}\right) & \text{if } w > \frac{p_2^2}{4p_1}. \end{cases} \tag{6}$$

Observe from (6) that for any w, p_1, there always exists p_2 (specifically, $p_2 < 2\sqrt{p_1 w}$) for which the optimal consumption choice has positive amount of good 2. In contrast, if $w \leq \underline{w}(p_1)$ for an SI preference, then *regardless of* p_2, the optimal consumption choice does not have good 2.

4.3 Subsistence inertia

Even if an individual has adequate income to buy more than subsistence level of good 1 so that good 2 can be beneficial, it might still be optimal to buy only good 1. We refer to such a situation by *subsistence inertia*. To see this, consider the utility function given by (2) in Example 2. In this case the unique solution to the utility maximization problem (3) is as follows where $\overline{w}(p_1) = p_1\overline{Q}$ and as before $\underline{w}(p_1) = p_1\underline{Q}$. For $p_2 < \overline{w}(p_1) - \underline{w}(p_1)$, we have

$$x^* = \begin{cases} \left(\frac{w}{p_1}, 0\right) & \text{if } w \leq \underline{w}(p_1), \\ \left(\frac{w}{p_1}, 0\right) & \text{if } \underline{w}(p_1) < w \leq \underline{w}(p_1) + p_2, \\ \left(\frac{w+\underline{w}(p_1)+p_2}{2p_1}, \frac{w-\underline{w}(p_1)-p_2}{2p_2}\right) & \text{if } \underline{w}(p_1) + p_2 < w < 2\overline{w}(p_1) - \underline{w}(p_1) - p_2, \\ \left(\overline{Q}, w - \overline{w}(p_1)\right) & \text{if } w \geq 2\overline{w}(p_1) - \underline{w}(p_1) - p_2. \end{cases} \tag{7}$$

For $p_2 \geq \overline{w}(p_1) - \underline{w}(p_1)$, we have

$$x^* = \begin{cases} \left(\frac{w}{p_1}, 0\right) & \text{if } w \leq \underline{w}(p_1), \\ \left(\frac{w}{p_1}, 0\right) & \text{if } \underline{w}(p_1) < w \leq \overline{w}(p_1), \\ \left(\overline{Q}, w - \overline{w}(p_1)\right) & \text{if } w \geq \overline{w}(p_1). \end{cases} \tag{8}$$

Observe from (7) and (8) that it may be optimal to buy only good 1 and no good 2 even if $w > \underline{w}(p_1)$. For $w \leq \underline{w}(p_1)$, it is optimal not to buy good 2 regardless of p_2. However, for $w > \underline{w}(p_1)$, like a quasilinear preference whether it is optimal to buy good 2 or not does depend on p_2.

4.4 SI preferences and child labor

SI preferences can be useful to understand the use of child labor for poor households. As in the child labor model of Basu and Van (1998) [BV], consider an individual household with two members: one adult and one child. The adult member works to earn adult labor wage w_A. Let $e \in \{0, 1\}$ be the choice of child labor for the household. If the household does not send the child for work ($e = 0$), the household's income is

w_A. If it sends the child for work ($e = 1$), the child member earns child labor wage w_C and the household's income is $w_A + w_C$.

Suppose the household has an SI preference where good 1 is food and good 2 is the time that the child does not spend at work. Assume that the child has one unit of indivisible time, so x_2 (the amount of time of the child not spent at work) equals $1 - e$. That is, $x_2 = 0$ if the child is sent to work and $x_2 = 1$ if the child does not work.

Let $\underline{Q} > 0$ be the subsistence threshold for the household and $p_1 > 0$ the price of good 1 (food). If the household does not meet its subsistence requirement, it only cares about good 1. Thus, if $w_A < \underline{w}(p_1) = p_1\underline{Q}$ (adult labor wage is insufficient to meet subsistence requirement), the optimal choice for a household would be to send the child to work to have a higher income $w_A + w_C$ to raise its consumption of good 1. This is consistent with the assumption of BV. However, BV also assume that once the adult labor wage is sufficient to meet the subsistence requirement, the household stops using child labor. This implies that once $w_A > \underline{w}(p_1)$ in the model of BV, the household does not use child labor even if w_A is only marginally higher than $\underline{w}(p_1)$. This implication is questionable for households on the margins of subsistence. We show that SI preferences can help to better clarify this issue.

Suppose the household has the preference of Example 1 and $w_A > \underline{w}(p_1)$. If the household sends the child to work, then $x_2 = 0$, its income is $w_A + w_C > \underline{w}(p_1)$ and by (1), its utility is $u^1 = \underline{Q}$. If the household does not send the child to work, then $x_2 = 1$, its income is w_A, it chooses $x_1 = w_A/p_1$ (which is more than $\underline{Q}$) and by (1), it obtains utility $u^0 = \underline{Q} + (w_A/p_1 - \underline{Q})^\alpha > u^1 = \underline{Q}$. This shows that for Example 1, it is optimal for the household to not use child labor whenever w_A exceeds $\underline{w}(p_1)$, as assumed in BV.

Next suppose that the household has the preference of Example 2 and $w_A > \underline{w}(p_1)$ but $w_A + w_C < p_1\overline{Q}$ (ensuring that saturation level $\overline{Q}$ of good 1 is not attained). If the household sends the child to work, then $x_2 = 0$, its income is $w_A + w_C > \underline{w}(p_1)$ and it chooses $x_1 = (w_A + w_C)/p_1$, so by (2), its utility is $u^1 = (w_A + w_C)/p_1$. If the household does not send the child to work, then $x_2 = 1$, its income is w_A, it chooses $x_1 = w_A/p_1$ and by (2), obtains utility $u^0 = w_A/p_1 + (w_A/p_1 - \underline{Q})$. Comparing u^0 and u^1, if $\underline{w}(p_1) < w_A < \underline{w}(p_1) + w_C$, it is still optimal for the household to use child labor, while if $w_A > \underline{w}(p_1) + w_C$, it is no longer optimal to use child labor. Thus, in contrast with the assumption of BV, a household may find it optimal to use child labor even if the adult labor wage exceeds the minimum income required to meet the subsistence requirement.

These two examples demonstrate that depending on their nature of substitutability between the basic good and the non-working time of the child, households on the margins of subsistence may differ on their use of child labor. SI preferences allow for such different possibilities that can be useful to better understand the use of child labor for poor households.

5 Concluding remarks

One question is to what extent the two-good setting of SI preferences can be extended to many goods. If there are multiple basic goods (food items) and multiple non-basic

goods (non-food items), still the same principle of subsistence applies: when subsistence requirement is not met, the individual exclusively cares about goods that contribute to nutrition, rendering other goods useless. However, some additional specification is needed. When there is only one food item, a monotonic relation between quantity of food and nutrition is enough to give us the threshold level of food that corresponds to the subsistence requirement. When there are multiple food items, we need to specify the functional relation between different food items and nutrition to determine the consumption bundles that correspond to the subsistence requirement. This is illustrated in the following example.

Example 3 There are three goods $1, 2, 3$. A consumption bundle is given by $x = (x_1, x_2, x_3) \in \mathbb{R}^3_+$. Goods $1, 2$ are basic goods (food items) and good 3 is a non-basic good (non-food item). The nutrition n depends only on the food items and it is given by the function $n(x_1, x_2)$. Let $\underline{Q}$ be the subsistence requirement of nutrition. If $n(x_1, x_2)$ does not exceed $\underline{Q}$, the individual exclusively cares about goods $1, 2$ and good 3 is not useful. Suppose for an individual, $n(x_1, x_2) = x_1 + x_2$ and his preference is represented by utility function

$$u(x) = \begin{cases} n(x_1, x_2) & \text{if } 0 \leq n(x_1, x_2) \leq \underline{Q}, \\ \underline{Q} + \left(n(x_1, x_2) - \underline{Q}\right)^{1/2} x_3^{1/2} & \text{if } n(x_1, x_2) > \underline{Q}. \end{cases} \tag{9}$$

Observe that when $n(x_1, x_2) = x_1 + x_2$ does not exceed $\underline{Q}$, the individual's exclusive concern is nutrition. Any consumption bundle x with $x_1 + x_2 \leq \underline{Q}$ is in the pre subsistence zone; any bundle x with $x_1 + x_2 > \underline{Q}$ is in the post subsistence zone.

Example 3 shows that with suitable specification of the functional relation between food items and nutrition, our framework can be extended to multiple basic and non-basic goods. The function $n(x_1, x_2)$ is linear in (9), so there the two food items are perfect substitutes in providing nutrition. Other functional forms are also possible (e.g., $n(x_1, x_2) = x_1^k x_2^{1-k}$, $n(x_1, x_2) = \min\{x_1, x_2\}$).

Finally we note that while food is certainly the most basic of necessities, other goods and services can be included within the ambit of basic needs to broaden the notion of subsistence.[9] For instance, in addition to food, housing can also be of primary importance for a worker who migrates from a village to a big city. Some additional considerations will arise to incorporate two different kinds of basic needs (nutrition and accommodation) within subsistence. Schooling is another example for which similar considerations will arise (see, e.g., Deaton and Drèze, 2009). Building on our basic framework, certain modifications will be required to address these issues.

Appendix

Proof of Observation 1 We prove (i), proof of (ii) is similar.

[9]The Sanskrit word for bare subsistence *grāsāććhādana* makes the components of subsistence particularly clear. It is a compound consisting of two words: *grāsa* (food) and *āććhādana* (clothing) (see p. 302, Williams, 1872). The definition of basic needs by the ILO includes food, clothing and shelter as well as essential services such as safe drinking water, sanitation and health and educational facilities (see, e.g., ILO, 1976; Cobbe, 1976; Jolly and Santos, 2016).

(i)(a) If good 1 is irrelevant at x, then for any $z_1 > y_1 > x_1$, we have $x \sim (y_1, x_2)$ and $x \sim (z_1, x_2)$. By transitivity, $(y_1, x_2) \sim (z_1, x_2)$. This shows good 1 is irrelevant at (y_1, x_2) for all $y_1 > x_1$, proving the if part of (a).

To prove the only if part, suppose good 1 is irrelevant at (y_1, x_2) for all $y_1 > x_1$. If, in contrary to the assertion, good 1 is relevant at $x = (x_1, x_2)$, then there is $t > 0$ such that $\hat{x} = (x_1 + t, x_2) \succ x$. As $\succsim$ is continuous, there exist neighborhoods $N_\varepsilon(\hat{x})$, $N_\varepsilon(x)$ such that any bundle in $N_\varepsilon(\hat{x})$ is strictly preferred to any bundle in $N_\varepsilon(x)$. Note that $\hat{x} \in N_\varepsilon(\hat{x})$ and there is sufficiently small positive $r < t$ such that $(x_1 + r, x_2) \in N_\varepsilon(x)$, so we have $\hat{x} \succ (x_1 + r, x_2)$. Since good 1 is irrelevant at $(x_1 + r, x_2)$, we must have $(x_1 + r, x_2) \sim \hat{x}$, a contradiction which proves the only if part of (a).

(i)(b) Suppose good 1 is irrelevant at (x_1, y_2) for all $y_2 < x_2$. If, in contrary to the assertion, good 1 is relevant at $x = (x_1, x_2)$, then there is $z_1 > x_1$ such that $\hat{x} = (z_1, x_2) \succ x$. As $\succsim$ is continuous, there exist neighborhoods $N_\varepsilon(\hat{x})$, $N_\varepsilon(x)$ such that any bundle in $N_\varepsilon(\hat{x})$ is strictly preferred to any bundle in $N_\varepsilon(x)$. Note that there is sufficiently small positive r such that $(z_1, x_2 - r) \in N_\varepsilon(\hat{x})$ and $(x_1, x_2 - r) \in N_\varepsilon(x)$, so we have $(z_1, x_2 - r) \succ (x_1, x_2 - r)$. Since good 1 is irrelevant at $(x_1, x_2 - r)$, we must have $(x_1, x_2 - r) \sim (z_1, x_2 - r)$, a contradiction which proves the result.

(i)(c) Suppose good 1 is relevant at x and in contrary to the assertion, there is some $a_1 < x_1$ such that good 1 is irrelevant at (a_1, x_2). Since $x_1 > a_1$, by part (a), good 1 must be irrelevant at $x = (x_1, x_2)$, which is a contradiction.

(i)(d) Suppose good 1 is irrelevant at $x = (x_1, x_2)$. If $x_1 = 0$, then taking $g(x_2) = 0$ proves the result. If $x_1 > 0$ and good 1 is irrelevant at (y_1, x_2) for all $0 < y_1 < x_1$, then by part (a), good 1 is irrelevant at $(0, x_2)$ and again taking $g(x_2) = 0$ proves the result.

So suppose $x_1 > 0$ and good 1 is relevant at (a_1, x_2) for some $0 < a_1 < x_1$. Then by part (c), good 1 is relevant at (y_1, x_2) for all $0 \leq y_1 \leq a_1$. Let

$$V(x_2) = \{y_1 \in \mathbb{R}_+ | \text{ good 1 is relevant at } (y_1, x_2)\}$$

Note that $y_1 \in V(x_2)$ for any $y_1 \leq a_1$ and $y_1 \notin V(x_2)$ for any $y_1 \geq x_1$. As $V(x_2)$ is a non empty subset of $\mathbb{R}$ which is bounded above by x_1, by the least-upper-bound property of $\mathbb{R}$ (see Theorem 1.19, Rudin, 1976), it has a least upper bound: call it $g(x_2)$. Note that $a_1 \leq g(x_2) \leq x_1$.

As $V(x_2)$ is bounded above by $g(x_2)$, any $y_1 > g(x_2)$ must be outside $V(x_2)$ which means good 1 is irrelevant at (y_1, x_2) for all $y_1 > g(x_2)$. Then by part (a), good 1 is also irrelevant at $(g(x_2), x_2)$. Thus good 1 is irrelevant at (y_1, x_2) for all $y_1 \geq g(x_2)$.

Finally observe that if good 1 is irrelevant at (z_1, x_2) for some $z_1 < g(x_2)$, then by part (a), $V(x_2)$ will be bounded above by that z_1. This is not possible since $g(x_2)$ is the least upper bound of $V(x_2)$. This shows good 1 is relevant at (y_1, x_2) for all $y_1 < g(x_2)$, proving the result. ■

Proof of Observation 2 To prove part (i), suppose on the contrary $\overline{Q} \leq \underline{Q}$. Consider any $x_2 > 0$. Using the properties of indifference curves illustrated in Figures 2(a) and 2(c), we will have a situation as in Figure 2(d). Take any $y_1 > \underline{Q}$. Since $\overline{Q} \leq \underline{Q}$, by property (c) of Definition 3, we have $(y_1, x_2) \sim (\underline{Q}, x_2)$. By property (a), $(\underline{Q}, x_2) \sim (\underline{Q}, 0)$, so by transitivity we have $(y_1, x_2) \sim (\underline{Q}, 0)$. Since $y_1 > \underline{Q}$ and $x_2 > 0$, this violates monotonicity (see Figure 2(d)). So we must have $\underline{Q} < \overline{Q}$.

To prove part (ii), consider any (x_1, x_2) for which $x_1 < \overline{Q}$. Note from property (c) of Definition 3 that good 1 is relevant at such (x_1, x_2), that is, there is some $y_1 > x_1$ such that $(y_1, x_2) \succ (x_1, x_2)$. If $y_1 \geq \overline{Q}$, then $(\overline{Q}, x_2) \sim (y_1, x_2)$ and if $y_1 < \overline{Q}$, by monotonicity $(\overline{Q}, x_2) \succsim (y_1, x_2)$. In either case, by transitivity we have $(\overline{Q}, x_2) \succ (x_1, x_2)$. This shows the indifference curve containing $(\overline{Q}, x_2)$ does not contain any bundle (x_1, x_2) for which $x_1 < \overline{Q}$. (see Figure 2(c) for an illustration of an indifference curve containing $(\overline{Q}, x_2)$ for a preference that satisfies property (c) of Definition 3).

■

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Declarations

Conflicts of interest On behalf of all authors, the corresponding author states that there is no conflict of interest. The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This study does not involve human participants, their data or biological material.

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