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Handprint-Based NetPositive Assessment

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Abstract: Every product has a "Carbon footprint" measuring the greenhouse gas emissions, a "water footprint" measuring water consumption, and so-on. And if every product has footprints, so does every person and every organization. While we can and must work to continually reduce them, we will never drive our footprints to zero. However, we can also bring positive change, benefits, healing to the world around them. Footprint-consistent estimates of the impacts of positive change are called *handprints*. If we shrink our footprints while also growing our handprints, we can eventually do more good than harm, becoming NetPositive. To manage for and achieve NetPositive, we need to be able to measure and reduce our footprints while measuring and growing our handprints. The ability to be NetPositive lies with actors or entities capable of creating change, not products, although actors will often create change through the *use* of products (goods and services). it is how, and in what context, a product is used (by actors) which determines whether that product's use creates benefits that exceed the costs of achieving them. HBNA takes the full life cycles of products into account. No part of a life cycle affected by a change or decision is out of scope – indeed, no impact caused by an actor is out of scope. There are two ways to create a handprint: (1) Preventing/avoiding footprints that would otherwise have occurred, which includes reducing the magnitude of footprints that occur, relative to what their magnitude would otherwise have been; and (2) Creating positive benefits which would not otherwise have occurred.

This paper has four sections:

- The Inevitability of Footprints
- Becoming NetPositive
- Basics of NetPositive Accounting with Handprints
- Equations for Product-Related NetPositive Assessment

The Inevitability of Footprints

Most human activities and all modern human lives require the use of goods and services. For example, working in an office makes use of a computer, desk, chair, lighting, and space conditioning, not to mention construction and maintenance of the building itself. Eating a meal at home requires the food, prior refrigeration of the food, energy to cook the food, dishes and utensils which must be washed after use, and more. Bicycling to work requires a bike, helmet, and space on a bike path or road. Even sleeping generally makes use of a bed, pillow, sheets and blanket, which must be washed and dried from time to time, and eventually replaced when they wear out.

The production of each of these goods and services generates negative impacts, such as pollution and the consumption of natural resources. Electricity generation from fossil fuels for example, releases greenhouse gases and other pollutants to air, occupies land, and generates wastes which must be disposed of. And each production process in turn requires the use of other goods and services, creating supply chains which span the economy and the globe. Generating electricity from coal or other fuel inputs means these fuels must be mined from the earth, refined, and transported to the point of use. Extraction of resources from the earth requires equipment which had to be manufactured, along with more energy, generating more emissions to air, water, and land.

We call the sum of these negative impacts from a production process and its vast supply chain the "footprint" of producing the good or service. Since the impacts are multi-faceted, so are the footprints. Every product has a "Carbon footprint" measuring the greenhouse gasses, a "water footprint" measuring water consumption, a "toxics footprint" measuring toxic releases to the environment, a "health footprint" measuring impacts on human health, a "biodiversity footprint" and so-on. And if every product has footprints, so does every person and every organization. While we can and must work to continually reduce them, ***we will never drive our footprints to zero. Sustaining a person and operating an organization inevitably causes harm, albeit unintended and regretted.***

For some impact categories, a nonzero footprint can be sustainably absorbed by the environment. For example, if groundwater withdrawals equal natural groundwater recharge rates there is no net depletion. Atmospheric concentrations of CO2 might be stabilized at low non-zero anthropogenic emissions levels as long as natural systems have not been pushed into unstable modes where warming brings accelerating biogenic emissions and/or decelerating sequestration. But for many impacts, any nonzero footprint is negative. Consumption – or more accurately, dissipative use – of non-renewable resources makes them unavailable to future generations. Burning wood or fossil fuels releases airborne particulates and pollutants that have no known safe dose. If you cook over a fire in the wilderness and remain upwind of your fire, the human health risk of that fire's pollution may approach zero; but we don't live in the wilderness.

Science-based setting of footprint reduction targets[1] is a valuable new perspective in at least two ways. First, it raises overall visibility and awareness of the fact that anthropogenic emissions of many pollutants and other substances are destabilizing global ecosystems and biogeochemical cycles and must be reduced. Second, it tends to drive companies to set more aggressive footprint reduction targets. However, until *all* actors are footprinting at science-based levels, even science-based footprints increase net harm.

[1] See, for example, http://sciencebasedtargets.org

Becoming NetPositive

If we cannot achieve zero footprint as people or organizations, does this mean that every person and every organization is doomed to be "bad news" for the planet and future generations? Thankfully, no. Although sustaining a person or an organization inevitably causes harm, these same people and organizations can also bring positive change, benefits, healing to the world around them. **If we shrink our footprints while also growing the amount of benefits we bring, we can eventually do more good than harm, give more than we take. If you give more than you take, you are a net contributor, you are NetPositive.**

We manage what we measure. To manage for and achieve NetPositive, we need to be able to measure the good we do in ways that are consistent with our measurement of the harm we cause, our footprints. ***Handprints are footprint-consistent estimates of positive change. If your handprint is larger than your footprints for a given impact category, then you are NetPositive for that impact category.***

Let's consider potable water. We all must drink to live. Our total potable water footprint drastically exceeds our direct consumption (whether to a person or to an organization) because of all the water required to operate the processes that produce the goods and services that sustain us. Can we possibly "give" more potable water than we take, create a water handprint greater than our total water footprint?

Being water NetPositive this year means literally that your actions this year cause more water to be made available in the world than is consumed by you directly and all the processes needed to sustain you during this same year. How can you cause a quantity of potable water to be made available in the world – a water handprint? By some combination of avoiding/preventing consumption by ourselves or others, or purifying water, or trapping potable rainwater that was otherwise destined to become unavailable as freshwater by flowing directly into the ocean for example.

Let's start with the first way to create a handprint: avoiding/preventing waste, where we consider waste in the broad sense of valueless consumption, excess consumption which brings no extra value. A handprint can for example be created if we replace one way of delivering value with another way that delivers the same (or more) value while consuming less. Showerheads sold in the US prior to 1992 consumed as much as 5.5 gallons per minute (gpm), when the limit became 2.5 gpm.[2] Showerheads now exist which can provide an equally satisfying cleansing experience with 1.5 gpm.[3] Although the production of a new 1.5 gpm showerhead has a water footprint, the water it saves in one year of typical use compared with even a 2.5 gpm showerhead exceeds the water footprint of producing it. If a less efficient showerhead already in use were otherwise (without us intervening) going to continue to be used for years to come, then replacing the less efficient ones with a new 1.5 gpm showerhead creates a water handprint – a footprint-consistent positive change. Install enough 1.5 gpm showerheads in place of less efficient ones that would have operated for more than a year, and you will have created a water handprint larger than your water footprint. You'll be water NetPositive.

2 http://energy.gov/energysaver/reduce-hot-water-use-energy-savings
3 http://www.sfgate.com/business/networth/article/High-Sierra-Showerheads-inventor-goes-with-flow-5432278.php

Basics of NetPositive Accounting with Handprints

This section addresses a range of topics which arise as we formalize handprint-based NetPositive assessment. These topics include:

- Who/what can be NetPositive?
- Life cycle scope for NetPositive assessment
- Ways to create Handprints
- Does reducing our footprint count as a Handprint?
- Handprints are for voluntary innovation
- Change and the counter-factual: defining Business-as-usual
- Causing a Handprint
- Shared responsibility in footprinting, shared credit in handprinting
- Handprint efficiency
- Three orthogonal uses of Time in NetPositive Assessment:
- NetPositive *when*
- Handprint timing
- Duration of influence
- Modes of Handprinting
- Handprint gratitude

Who/What Can Be NetPositive?

NetPositivity is positive change that exceeds the impacts necessary to enable it. For this reason, the ability to be NetPositive is restricted to actors or entities capable of creating change. While individuals, groups, organizations and products can and have been framed as having footprints, in Handprint-based NetPositive accounting (HBNA) the focus is on actors or entities. Of course, actors will often create change through the *use* of products (goods and services), but we still refer to the handprints as being created by the actor, not by the product itself. Another reason for the focus on actors rather than products is that **it is how, and in what context, a product is used (by actors) which determines whether that product's use creates benefits that exceed the costs of achieving them.**

Life Cycle Scope for NetPositive Assessment

HBNA takes the full life cycles of products into account. No part of a life cycle affected by a change or decision is out of scope—indeed, no impact caused by an actor is out of scope. That said, the scope of *footprint* assessment in HBNA consistently focuses on what is called the cradle-to-gate portion of product lifecycles. This is in contrast with the less consistent scope definition used in footprint assessment to date, before the advent of handprint assessment. In pre-HBNA footprinting practice, footprint scope is defined as being cradle-to-gate, except when it needs to include the use phase and/or the end-of-life phase. The need to expand the scope to is then established on a standard-by-standard basis in a sector-specific way; for example the GHG protocol for carbon footprinting calls for inclusion of the use phase if the product consumes energy during its use phase, but not if use of the product influences the energy use of some other product or process. We understand that without handprints, the above approach seemed like the only way to encourage companies for making progress on the use phase impacts of their products, but we also note that this approach is both inconsistent and incomplete. In HBNA, a consistent and logical cradle-to-gate footprint scope poses no problems of incompleteness because the scope of handprinting always includes direct and indirect influences across the scope of the total life cycle.

In handprint-based NetPositive accounting, we define the footprint of an entity in a way that is logically consistent across all cases: the sum total of the negative impacts caused by all the processes needed to sustain and enable that entity to offer what it does to the world. For a company or organization, this can be referred to as the sum total of the negative impacts caused in order to enable that organization to operate and perform its mission. In life cycle assessment (LCA) parlance, this is the “cradle-to-gate footprint” for the entity. And in GHG protocol parlance, this is the Scope 1 + Scope 2 plus Scope 3 upstream footprint. Notice that the footprinting system accounts for two ways that consumers and producers influence the world: by causing direct impacts through their own operations, and by causing indirect impacts via purchasing from other producers.

We define the handprint of an entity as the **footprint-consistent impacts of changes caused by the entity, relative to what would have happened without the entity being an agent of change.** The handprint of an entity is the net change brought about by that entity – hopefully but not necessarily positive or beneficial – measured in the same impact units as used in footprinting. The scope of the system includes any and all causal pathways by which the causes changes in impacts. Thus, one such set of pathways is the same set of pathways included by footprinting: direct impacts of operations, and indirect impacts via purchasing from other producers. Handprint system scope also includes other, equally impactful ways that companies and production can exert influence on the world. In so doing, it opens up a wider realm of pathways for positive influence. While footprinting encourages us (holds us responsible) to reduce the impacts occurring in our supply chains, handprinting encourages us to be a cause of positive change anywhere and everywhere in the world, both within and outside of the life cycles of the goods and services that we produce and consume. In HBNA, we refer to this broader set of impact-generating influences “ripple effects.” If a company makes the use phase of its product more (or less) efficient, the impacts of this change are part of its handprint. If the company uses information flows to affect how its own or other products are used, or managed at their end-of-use, these impacts are part of its handprint. Information can inspire, inform, encourage, or enable change.

Notice that just as commerce stimulates more commerce in supply chains, positive ripple effects can stimulate more positive ripple effects in the world too. For example, let’s say an entity encourages some customers to co-create handprints, by using their product more efficiently. If this initial encouragement leads these customers to get active in creating other handprints, those are part of its ripple effect. And if their handprinting stimulates other people and companies to get involved in handprinting, their positive influence spreads further.

Information is one very powerful path for being a cause of positive change. Other paths are perhaps more physically tangible, such as contributing the labor and/or investment funding needed to make positive change happen. In its simplest form, investment is a “one-shot deal,” yielding a single change; for example, funding might be provided to enable a homeowner to invest in energy efficiency. However, with clever program design, a single initial investment can lead to exponentially growing ripple effect handprints. This can be done for example by capturing a portion of the economic savings that result from increased energy efficiency, and re-investing these savings in the purchase of more energy efficiency in other homes. If the savings from each investment are greater than the initial investment, this can lead to self-amplifying ripple effects, as one investment leads to two more which lead to four more, etc. This is a case where an initial handprinting investment creates abundance, some of which is harnessed to create more abundance, and so on. Since all the follow-on investments are co-caused by the initial investment, the impacts of these follow-on investments are part of the initial investment's handprint.

Note that, by including influences of the company anywhere in the world, including the life cycles of its products, HBNA holds companies accountable for both positive (and negative) changes which they may make to the use phase and end of life impacts of their products, whether these bring changes to direct impacts of their own product life cycles, or changes to the impacts of the life cycles of other products. For this reason, the HBNA framework is more comprehensive than the original footprinting-only frameworks, *and* it is able to operate with a single, stable, logical and consistent definition of footprints. Footprints are the impacts caused by enabling the entity to live or operate, and handprints are the impacts of the changes that entity causes in the world while operating.

Ways To Create Handprints

There are two ways to create a handprint:

- Preventing/avoiding footprints that would otherwise have occurred (this includes reducing the magnitude of footprints that occur, relative to what their magnitude would otherwise have been)
- Creating positive benefits which would not otherwise have occurred

It is helpful to use the shorthand term "business as usual" (abbreviated as "BAU") to refer to "what otherwise would have occurred. Using this, we can express the two ways for creating handprints as:

- Reducing total footprints relative to BAU
- Creating positive benefits relative to BAU

Does Reducing Our Own Footprint Count as a Handprint?

The goal of HBNA is to guide actions that ultimately enable each person and organization to provide net benefits to the world, on as many impacts as possible. We achieve NetPositive when the "costs" (negative impacts) of us being here are exceeded by the benefits (positive impacts) of us being here.

One scoping question for NetPositive accounting is whether or not an entity should get handprint credit for reductions it makes in its own footprint. Put simply, do we get credit for cleaning up our own mess? Two perspectives on this question are possible and defensible. It all depends on whether we consider the existence of the person or organization to be a legitimate part of business-as-usual.

If we take the entity's existence as a given, then reductions to *any* negative impacts are a benefit for all, whether they occur within the scope of the entity's footprint or not. NetPositive from this perspective means "giving more than you take" or "doing more good than harm."

A second way to define NetPositive is "making the world better off with you than without you." In this case, one scenario has you (or your organization) absent from the earth, while the other has you present, both polluting and making reductions in the footprints of others. If you didn't exist, then you'd have no footprint at all. So from this second perspective, you don't count reductions in your footprint as part of your handprint.

At this point in the development of Handprint-based NetPositive Assessment, it seems reasonable to allow both perspectives as possibilities, and to simply call on communications of NetPositive assessment to make it clear and transparent which of the two perspectives is being adopted.

Handprints Are For Voluntary Innovation

Handprints are for changes that are voluntarily brought about – changes that would not happen without intentional and voluntary action on the part of the actor. Thus, reductions in product environmental footprints that are achieved in order to comply with regulations do not count towards handprints. Reductions which arise due to improvements which *go beyond* those required by law do qualify, in that the beneficial impacts of the "excess improvement" count toward handprints.

Change and the Counterfactual: Defining Business as Usual

Handprints are created when change is caused. This begs the question: change relative to what? Relative to last year, or relative to some base case forecast of impacts for this year? If relative to a base case forecast, how is this forecast obtained? In answering these questions and defining business-as-usual it is helpful to consider specific ways that handprints can be created. Product-related handprints for example can be created through a combination of the following interventions:

- Improving the life cycle performance of an *existing* product through innovation, so that future demand for the product is met by an improved solution rather than the pre-innovation solution.
- Introducing a *new* product which performs better than other product(s) on the market whose demand it displaces.
- Increasing demand for an *existing* product at the expense of demand for other product(s) on the market which perform worse than the subject existing product.

In the first published explanation of Handprinting methodology, Norris (2013) suggested that product-related business-as-usual (BAU) for companies would consist of responding to next year's demand with this year's products and processes. This definition allows that demand for a company's product is often largely exogenously determined. This simple approach to BAU applies reasonably well to cases where a product is already being sold by the company, and neither the innovation nor other actions by the company alter demand appreciably. While this simple approach addresses an important subset of product-related cases, other cases require a different BAU scenario.

For example, companies can introduce new products into a market. In this case, the base case is a forecast of market demand and market shares absent the new product introduction, and the life cycle impacts of the products sold on that market in the years of assessment. The newly introduced product will then displace some of the demand for the other products on the market. As another example, companies can actively intervene in ways that seek to influence demand for one of their existing products at the expense of other products on the market. Here again, the base case is a forecast of market demand and market shares, and the life cycle impacts of the products sold on that market in the years of assessment.

For handprinting at the personal level, Norris (2013) suggested that a simple and practical BAU is provided by last year year's consumption. Sustainable consumption research has shown that over the course of a person's life, as well as cross-sectionally across a group of individuals, disposable income is a strong predictor of annual footprint. Both disposable income and annual footprint tend to rise and then fall in tandem over the course of a lifetime, but in most years, the change from one year to the next is gradual.

Causing a Handprint

It is common for events to have multiple causes. In Handprinting we attribute handprints (and thus causation) to actors: individuals, to groups of individuals, and to organizations. Products can be instrumental in how the actors actually create change, but they are not cited as being direct causes themselves. Causers of a handprint are actors about whom we can say: the handprint would not have happened without their influence. The handprint that they cause becomes part of their total handprint.

Causers can be distinguished from enablers, about whom we can say: "it happened in part through the use of their product." While enabling a handprint is not causing a handprint, enablers of handprint-creating actions can and do play an important role in the handprinting system. As a seller of a products that may enable handprinting actions, they are in a position to benefit (by selling more product) by promoting the demand for handprinting. They may also be able to provide training or advice to users of their product in ways that *increase* their customers' handprinting activity, and if by doing so they can demonstrate that they have been a cause of this increase, the handprint of the increase becomes part of their handprint. Finally, they may be able to redesign their product so that it becomes a more effective enabler of handprinting; if there is a resulting increase in the amount of handprinting that occurs, directly attributable to the product redesign, this increase becomes a handprint of the enabler.

Shared Responsibility in Footprinting, Shared Credit in Handprinting

Footprinting *attributes responsibility for a given impact to multiple actors*. For example: a steel producer's footprint includes all of the pollution from their factory. The footprint of car producer includes that portion of the steel producer's pollution which is attributed to producing the steel purchased by the car producer. The footprint of the car buyer includes one car's worth of the steel producer's pollution as well. Thus, in Footprinting, we routinely say that many actors are *each* responsible for the same impact. This is *shared responsibility.* Putting this another way, the same unit of pollution – let's say 1 kg of CO_2 released in making steel – is part of the footprint of many different actors in the economy. Shared responsibility takes account of the fact that events can have multiple causes, and that some events cause other events, leading to long chains of causal influence.

This sharing and multi-attributing of responsibility has the positive characteristic that Footprinting can motivate every actor whose decisions could improve (reduce) impacts to do so. But with shared responsibility, if we are trying to understand the Footprint of a group of people, or a group of organizations (e.g., everyone in a family, or every organization in a city), we need to exercise some care in our accounting. This issue rarely comes up in LCA because we tend to use it to support a specific single decision by a single actor. Nor does it generally arise in Footprinting, because we tend to use Footprinting to assess the impact and responsibility of a single company, operation, or product – not the footprint of a whole group of companies.

Because of multiple attribution, when we want to assess the Footprint of a set of actors, we cannot just sum their individual footprints. Instead, we need to calculate the footprint of the *union of their activities.* The difference between a "union" and "sum" is that a union takes account of the unique identity of each event whose impacts we are summing, and counts the impacts of each unique event only once. The purchases made by the steel producer in a year *include* those which are stimulated by the car producer to whom they sell steel. Therefore, the collective Footprint of the steel producer and car producer as a group would sum the impacts of the steel producer (and its supply chains) plus the impacts of the car producer and of all of its *non-steel* purchases – since the impacts of its steel purchases were already accounted for when addressing the Footprint of the steel producer.

Turning next to Handprinting, we again find shared responsibility; and since Handprint impacts are generally positive, we can call it *shared credit*. Every causer of a Handprinting action can take credit for the positive impacts of that action as part of their handprint. Thus, the total Handprint of a set of actors can be less than the sum of their individual Handprints, *if* there is any overlap in their responsibilities – meaning, *if* their Handprints include any of the same unique events. As with Footprinting, accounting correctly for their shared Handprint is done by avoiding double-counting of the impacts of the same event, which can be done by preserving information about the uniqueness of each event, and counting the impacts of each event only once.

For some products, a major portion of the life cycle impacts occurs during the usage phase. How are handprint and footprint accounting affected for the buyer of a product, when the product's handprint includes the effect of reductions to its usage-phase energy? If our goal is to estimate the total handprint of the product manufacturer and the customer together, we would avoid double counting the usage phase innovation benefits, as we do in *all* cases of footprint and handprint aggregation, by finding the *union* of the handprints in ways that maintain the unique identity of the event of reduced usage phase energy.

Handprint Efficiency

Ultimately, the goal of being NetPositive as an individual person or organization is hollow if the overall system we are part of does not also achieve NetPositive, because the goal indeed is to leave the planet and its web of life in better shape tomorrow than today. We want the system, the whole, the community of which we are a part, to be NetPositive. In other words, we want the Handprint of the community to be greater than the Footprint of the community.

We have shared responsibility in footprinting, so the sum of the individual actor footprints can be an overestimate of the community's footprint. Likewise, we have shared credit in handprinting, so the sum of the individual actor's handprints can be an overestimate of the community's handprint. In assessing community NetPositivity (comparing the community's footprint to its handprint) we might hope that the double-counting in both Footprinting and handprinting might balance and cancel out, so that the achievement of NetPositivity by each actor indicates that the community is achieving NetPositivity. But in case multiple attribution is more prevalent in handprinting than footprinting for a given community (for example, within a social network of individuals who share a lot of mutual influence but who tend not to participate strongly in each other's footprints), we might ask for a more conservative guide.

As discussed above, perfectly avoiding double-counting when aggregating both handprints and footprints over a group can be achieved through careful accounting which takes into account the unique identity of each negatively and positively impacting event in the system. This careful accounting as a group would require that the calculation be performed at the level of the group, and with data including the unique identities of each handprinting action. How can individual members of such a group individually maintain a sense of the group's overall likely progress towards NetPositivity? The concept of *handprint efficiency* can be used to help assess progress towards community NetPositivity in a way that avoids the data burden of taking the unique identify of each impactful event into account.

We define the "efficiency" (e) of a handprinting action as the ratio of its handprint to the footprint of all the actors who share credit for accomplishing it. That is, for a handprint which was co-caused by *n* different actors, the efficiency of this handprint is

$$e = HP / \text{sum } [i=1,...n] \ FP_i$$

A handprint achieved by a single actor will by definition have an efficiency of 1. As the community responsible for co-creating a handprint grows, the efficiency of that handprint goes down. The handprint efficiency can be calculated at the time of each handprinting action, and retained as local information by each actor. Conceptually, if the members of a community of 10 persons co-create all of their handprint actions together (perfect shared credit) while having equal footprints with zero shared responsibility among their footprints, this community will be NetPositive if their *individual efficiency-weighted handprints* exceed their individual footprints. When there is little footprint overlap among the members of a handprinting community, it is prudent for the members of this community to each compare his or her individual efficiency-weighted handprint with their individual footprint as a measure of how well the group as a whole is moving towards NetPositivity.

Three Orthogonal Uses of Time in NetPositive Assessment

NetPositive When

To assess for NetPositive, we need to compare footprints and handprints created during the same period of time by an entity or group of entities. The most common time frame for assessing the footprints of organizations is annual. Thus, we adopt this same convention in assessing the Handprints of organizations and other actors, and in assessing whether these organizations and other entities are NetPositive. In this case, what we are assessing is whether the entity is NetPositive for that year, by generating a handprint that year which exceeds its footprint for that year. Other time frames are possible, of course.

Timing of Handprints

A product-related action often has consequences which play out over the life cycle of the product. For example, a home owner can install a water heater insulation blanket. The blanket will then save energy by reducing standby heat losses from the hot water tank, for as long as the blanket is in place. The question arises: when should the lifetime energy savings handprint of the water heater blanket be counted as a handprint for the actor: at the time (or during the year) when the blanket is installed, or year by year as the energy is saved? Both options are possible, and each has its particular advantages.

The first approach, counting the life cycle handprint all during the year of installation, is called the sales-year method. A primary strength of this method is its simplicity. The second approach, counting the impacts during each year in which they occur, is called the impact-year method. It has the advantage of being explicit about the actual timing of the expected impacts, which is particularly valuable for long-lived products. Making the timing explicit can be relevant for climate policy for example, and also in highlighting the potential influence of context variables in altering the actual handprint which occurs. As an example of the latter, the handprint of a long-lived product which will save electricity depends in turn on which fuel(s) will be used to generate the electricity during the life of the product, and this may change across the product life time.

Duration of Influence

Finally, there is the question of the duration over which the influence of a change persists, in relation to business as usual. For example, when a product design is improved by innovation, the newly innovated product will often be sold for multiple years. How many years of sales of the innovated product can count towards the handprint of this innovation? Clearly more than one year of sales is affected, but also clearly, the product will eventually be retired and replaced by still newer products, either from the same company of from competitors. The "Innovation-Relevant Time Horizon", or IRTH, is the term we give to the duration of time over which sales of an innovated product contribute to the total handprint of the innovation. We suggest that the proper value for IRTH's will vary by product type, and will be shorter for product types for which innovation cycle times are shorter.

The Behavior—Infrastructure Spectrum

Handprints can be created through very different modes of influence. For example, some handprints consist primarily or totally of behavioral change by a user of a product, while other handprints have little or no behavioral content to them. Switching the transportation mode for traveling to work has a strong behavioral aspect to it, as do changes in diet. Lasting behavioral change is often achieved through habit formation or habit alteration, which generally takes commitment and persistence over time to be cemented.

In contrast to strongly *behavioral handprints*, some other handprinting actions have virtually no reliance on influencing behavior. We might call these *infrastructural handprints*. An infrastructural handprint example is installing a water heater blanket. Once the blanket is in place, it will save the energy it is expected to save over at the remaining life of the water heater without any further behavioral effort by the blanket's installer. Indeed, it would take more effort to remove the blanket than to leave it in place! Note that both behavioral and infrastructural handprints are relevant to both the production and consumption contexts, or the at-work and at-home contexts.

Handprint timing and influence duration appear to require different treatment for behavioral versus infrastructural handprints. For an infrastructural handprint at the point of infrastructure use, the duration of influence is set by the product's life cycle, and the infrastructural nature of the handprint makes its lifetime influence relatively reliable to estimate at the moment the action (e.g., purchase or installation or alteration of a given piece of infrastructure) takes place. As noted above, for production-side handprints created through product-related redesign or innovation, the duration of influence for the innovation is given by the product category-specific innovation-relevant time horizon.

For behavioral handprints, until a habit has been lastingly formed (or a habit change lastingly achieved), it is prudent to claim only short term credit for the planned or intended behavior change. Consider a person making the decision to become a vegetarian, or bike to work. They might estimate and claim the handprint credit for doing so one week at a time for a while, and then extend this to monthly credit for a while. As months accumulate, the change starts to impact multiple years, and a new question arises: for how many years does such behavior change reflect a change to BAU? We leave this as an open question at this point, noting simply that the design of handprint assessment methods should ultimately serve the purposes of most effectively inspiring true benefit creation, meaning that it must reflect the multiple virtues of practicality, simplicity, credibility and accuracy.

Equations for Product-Related NetPositive Assessment

Handprints can be created by a combination of product-related factors, including:

- Improving the life cycle performance of an *existing* product through innovation, so that demand for the product is met by an improved solution
- Introducing a *new* product which performs better than other product(s) on the market whose demand it displaces
- Increasing demand for an *existing* product at the expense of demand for other product(s) on the market which perform worse than the subject existing product

In certain cases, only one of the above factors will be active, while in other cases, multiple factors will be active at once. The equations specified here apply to both single-factor and multi-factor scenarios.
The footprint of a product is a cradle-to-grave (or cradle-to-end-of-life) calculation. Product-related handprints thus take the full life cycle of the product into account as well:

$$\text{Handprint} = F_b - F_n \tag{1}$$

where

F_b is the Business-as-usual footprint of the product over its lifecycle, and
F_n is the New Footprint of the product over its life cycle

As noted earlier, Handprints are calculated relative to a specific impact category. In the discussion below, for brevity we omit repeated mention of this fact.

Functional Demand and Market Demand

Market demand for a product category can be expressed as the product of the demand for the function(s) that it delivers, times its "functional share" on each of those functions. For example, the demand for bus rides will be a product of what transportation planners call the "trip demand" (an example of functional demand) times the market share for bus rides in the relevant transportation market. As also discussed earlier, sometimes the total market demand for a product category is driven by demands for more than one function. The total demand for bicycles for example will be a function of the demand for bicycle-relevant transport (trips which can feasibly be made by bicycle) and the demand for bicycle-relevant recreation/sport activities. If the demand for either of these functions goes up (all else being equal), or the functional share of bicycles for either of these functions goes up, then the demand for bicycles will rise.

Given fixed total market demand for a product category, our product innovation could take or give a portion of a particular subset of the market, for which we need to calculate a factor for the expected impacts per unit of demand since leaving this market share unperturbed is part of the business as usual scenario. Given fixed total functional demand (but allowing that our innovation may affect demand for different types of solution, different markets, that serve the function), our product innovation could take or give a portion of a particular subset of the functional demand (for which we need to calculate a factor for the expected impacts of a unit of demand).

Affordability, Functional Demand Changes, and the Rebound Effect

There is the possibility that a product innovation will change total market demand while leaving functional demand relatively unchanged. For example, introducing a significantly more economical car may increase the total market demand for cars at the expense of other ways to provide the function (personal transport) that cars provide (bus rides, bike rides, etc.). There is also the possibility that a new innovation may alter the level of the underlying functional demand itself. More efficient cars may be enough to encourage some people to relocate their residence to a location farther from their work, or to take a job which requires a longer commute, both of which will drive up the total demand for person-km of personal transport. Rendering a function more affordable relaxes budget constraints on functional demand. [add citations for rebound effect here.]

The framework presented below includes dynamic and potentially exogenous (influenced by other variables within the system or scenario) total market demand for the subject product category. Market demand may in turn be expressed as functional demand multiplied by functional share, with both of these variables being dynamic and potentially exogenous as well, potentially influenced by the innovation whose impacts are being assessed.

Thus, in the most general case, Total Demand $D_k(t)$ for product *k* is the sum over all functions (i) of the functional demand $F_i(t)$ times the functional share $s_{ij}(t)$ for product category *j* (the share of function *i* which is met by product category *j*) times the market share $m_{ijk}(t)$ for product *k* on function *i.*

In most cases a handprinting action is likely to address a single functional demand category, either because the product only addresses a single main function, or because the handprint-related action is in relation to a single functional demand category. In this case, the equation for total demand $D_k(t)$ for product *k* is given by

$$D_k(t) = F(t)\ s_j(t)\ m_{jk}(t) \qquad (2)$$

where

$F(t)$ is the (dyamic) functional demand,
$s_j(t)$ is the functional share for product category *j* (the share of functional demand which is met by product category *j*), and
$m_{jk}(t)$ is the market share for product *k* on product category *j* for the given function.

Handprint Calculation Under Fixed Market Demand (But Flexible Market Share)

We specify an equation that addresses both new products and existing products, and cases that change the product's market share as well as cases that do not. Finally, the calculation addresses cases where the improvement is strictly one of altering market share alone, such as increasing market share for a greener-than-displaced product, or reducing market share for a less-green-than-displaced product.

Case 1: The General Case: Demand-Altering Product Change

In this case, an existing product is innovated in such a way that its total life cycle footprint is reduced. The innovation may have the effect of leading to changes in demand for the innovated product, either increased or decreased. For example, an innovation may make the product more attractive to buyers for one or more reasons such as better performance, lower purchase price, lower the total cost of ownership, and/or improved (reduced) environmental footprint. This increase in attractiveness to buyers may in turn bring an increase in market share for the product. Alternatively, the innovation might actually decrease market share for the product, if for example the innovation makes it more expensive. Our calculation method should allow for both positive or negative changes in market share.

In this first round of equations, we assume that total market demand, while it can be dynamic due to influences beyond the company's control, is unaffected by the innovation; we relax this assumption in a later equation.

Recalling from equation 1 that Handprint = $F_b - F_n$, we now specify F_b and F_n as follows.

F_b, the business as usual footprint, is given by

$$F_b = D_o I_o \tag{2}$$

where

D_o = business as usual demand for the product to be changed, and

I_o = business as usual impact of the product per unit of demand

Note that business as usual demand for the product may not be constant from year to year, due to exogenous influences. Thus, we specify exogenously dynamic total market demand for all products on the market (or all products serving the subject function) as D(t), and we specify business-as-usual demand in year (t) as $m_o D(t)$. Given this generalization, the business-as-usual footprint of the product in year (t), $F_b(t)$ becomes

$$F_b(t) = m_o\, D(t)\, I_o \tag{3}$$

where

m_o is the pre-innovation market share for the product

D(t) is the dynamic total demand for all products on the market in year (t)

I_o is business as usual impact of the product per unit of demand

F_n, the new footprint after we make one or more positive changes, is given by

$$F_n = D_1 I_1 + (D_o - D_1)\, I_a \tag{4}$$

where

D_1 is the new, innovated, demand for the product

I_1 is the new, innovated, impact of the product per unit of demand, and

I_a represents the impacts of the other products on the market whose demand is affected by the product and/or demand change being assessed. If demand for a diverse set of other products is affected, I_a represents the demand-change-weighted impacts of that set, or the average impacts for a random and representative sample of the impacted products.

As was the case for business-as-usual demand, we make the altered footprint dynamic by taking into account exogenous influences on total market (or functional) demand, allowing total market (functional) annual demand to be dynamic, expressed as D(t). Given that the product innovation may alter the product's market share, we specify the post-innovation market share for the product as m_1 . The innovation-altered demand in year (t) is then given by $m_1 D(t)$. And in this case, the dynamic equation for the new, post-innovation footprint in year (t), $F_n(t)$ becomes

$$F_n(t) = m_1 D(t)\, I_1 + (m_o - m_1)\, D(t)\, I_a$$

$$= D(t)\,[m_1 I_1 + (m_o - m_1)\, I_a] \quad (5)$$

where

- D(t) is the dynamic total demand for all products on the market in year (t)
- m_1 is the new, post-innovation market share for the product
- I_1 is the new, innovated, impact of the product per unit of demand, and
- I_a represents the impacts of the other products on the market whose demand is affected by the product and/or demand change being assessed; if demand for a diverse set of other products is affected, I_a represents the demand-change-weighted impacts of that set, or the average impacts for a random and representative sample of the impacted products.

Note that if D_1 is greater than D_o, then demand for the other products on the market has been reduced by the demand change, and this difference ($D_o - D_1$) will be negative. If D_1 is less than D_o, then demand for the other products on the market has shifted away from the new product to the other products on the market, and ($D_o - D_1$) will be positive.

Expressing this in terms of dynamic exogenous demand, if m_1 is greater than m_o, then market share for the other products on the market has been reduced by the innovation, and $(m_o - m_1)$ will be negative. If m_1 is less than m_o, then market share for the other products on the market has increased at the expense of market share for the innovated product, and $(m_o - m_1)$ will be positive.

The handprint H can be expressed as

$$H = F_b - F_n$$

$$H = D_o I_o - \{D_1 * I_1 + (D_o - D_1) * I_a\}$$

$$H = D_o (I_o - I_a) + D_1 (I_a - I_1) \quad (6)$$

And the dynamic handprint H(t) can be expressed as

$$H(t) = D(t)\,\{m_o (I_o - I_a) + m_1 (I_a - I_1)\} \quad (7)$$

Equation 7 is a general equation as we will see, that applies to all cases as long as the evolution of total (dynamic) market demand D(t) is unaffected by the innovation or change.

More Specific Handprinting Cases

No Impact on Market Share

It is possible that the innovation has no impact on market share. For example, the innovation may be effectively "invisible" to customers, or it may alter characteristics of the product that have no measurable influence on demand for the product. If market share is unaffected by the innovation or product change, then $m_1 = m_o = m$, and equation (7) simplifies to:

$$H(t) = D(t)\{m(I_o - I_a) + m(I_a - I_1)\}$$

$$= D(t)\, m\, (I_o - I_1) \qquad (7a)$$

Impact is purely one on market share

Another special case is that the product-related change is simply one of altering market share. For example, the firm may provide training or undergo a marketing campaign to increase demand for the product, but in the context where total functional demand is fixed. In this case, the impacts of the product per unit of demand are fixed, $I_1 = I_o$ and by using I_o in place of I_1 in equation (7) we obtain:

$$H(t) = D(t)\{m_o(I_o - I_a) + m_1(I_a - I_o)\}$$

$$= D(t)\,(m_o - m_1)\,(I_o - I_a) \qquad (7b)$$

Introduction of a New Product

Finally, consider the case that the innovation brings a new product to (an existing) market, or at least introduces a new way to provide a function for which the total functional demand is fixed. Since the new product is displacing demand for some set of existing products, the footprint for the demand that is met by new product sales would have been (in absence of the new product) $D_1 I_a$. That is, $D_o I_o$ is properly expressed as $D_1 I_a$. But instead, the footprint for the demand met by the new product is $D_1 I_1$. The handprint of the new product introduction is thus the difference between these, or $D_1 I_a - D_1 I_1$, which is $D_1 (I_a - I_1)$.

Making this dynamic, where D_1 is equal to m_1 D(t), we have

$$H(t) = m_1 D(t)\,(I_a - I_1) \qquad (7c)$$

The result above is precisely what we obtain if we substitute $D_1 I_a$ in place of $D_o I_o$ into the static general equation (6), or if we substitute m_1 in place of m_o and I_a in place of I_o into the dynamic general equation (7).

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