Culture, Supply Chain and Sustainable Food Consumption

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WP 2025 - Nr 07

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Giorgio Fabbri[†] and Paolo Melindi-Ghidi[‡]

Abstract

The transition towards a sustainable food system requires comprehensive changes in food production and consumption, shaped by the interplay of public policy, market forces, and cultural norms. We develop a model to analyse the role of sustainable food culture in shaping consumption choices, particularly in terms of purchasing from short food supply chains. The model accounts not only for the heterogeneity of preferences and their evolution but also for the heterogeneity of incomes. This allows for a discussion of the effectiveness of policies fostering sustainable food consumption choices, considering their varying impacts across income levels. The results suggest that if policy makers seek to promote a sustainable food system, public policies must be carefully designed, as their effects can be uncertain and may impact low-income households.

JEL Classification: Q18, Q56, D31, D91

Keywords: Culture, sustainable food, short food supply chain, income distribution.

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*The work of Giorgio Fabbri is partially supported by the French National Research Agency in the framework of the "Investissements d'avenir" program (ANR-15-IDEX-02). Paolo Melindi-Ghidi acknowledges financial support from the French government under the "France 2030" investment plan managed by the French National Research Agency Grant ANR-17-EURE-0020, and by the Excellence Initiative of Aix-Marseille University - A*MIDEX.

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1 Introduction

Food is at the heart of the sustainability issue. Transforming food systems and promoting sustainable consumption and production have taken centre stage in global political agendas. Initiatives like the UN Sustainable Development Goals or the Farm to Fork Strategy of the European Green Deal underscore the need for profound environmental changes in consumption choices, production methods, and supply chain practices. Poore and Nemecek (2018) estimate that food systems are responsible for approximately one-quarter of global greenhouse gas emissions. Crippa et al. (2021), report an even higher share, attributing 34% of global emissions to food systems. In addition to the emissions generated, the food system is linked to several sustainable development objectives such as no hunger, good health and protecting the planet, leaving no one behind. The scientific literature also suggests that the food system transformation requires broader systemic changes in both food production and consumption (Zurek et al., 2022) and it is driven by the interaction between public policy, the private sector, and culture (Moberg et al., 2021). Attempting to influence the cultural values that determine preferences in terms of food consumption choices is thus one of the key drivers for promoting the system transformation process.

The economic literature studying the transformation of the food system focuses mainly on analysing the shifts from unsustainable practices to cleaner alternatives (Polasky et al., 2019) without considering the role of cultural values in shaping individual food preferences. In this paper, we take a different view. Unlike previous studies mainly focusing on technological innovations and supply-side adjustments (Herrero et al., 2020), we study how the interaction between cultural factors, socio-economic conditions, and the market shapes the transition toward a sustainable food system. More precisely, we develop a theoretical framework where consumers have heterogeneous incomes and food preferences to explore how cultural values for sustainable consumption, such as consuming local production, intersect with the supply chains. By analysing these interactions, we aim to offer a full-fledged model in which food supply chains co-evolve with consumers' preferences for sustainable food, which can be related to environmental awareness, health considerations, and support for the local economy. This framework allows us to analyse various policy tools to promote food products from the short food supply chain (hereafter SFSC) and preferences for sustainable consumption, highlighting income redistribution's importance in designing public policies. We demonstrate that public policies to promote sustainable behaviours in food consumption require careful consideration, as their effects on adopting a sustainable food culture may be uncertain, with potential negative socio-economic impacts. We claim that if policymakers seek to promote a sustainable food system, they must ensure that the benefits of local food consumption are more accessible across income groups.

In our theoretical framework, two versions of the same good in the economy can be locally or non-locally produced. We define non-locally sourced goods as *'conventional'* goods. We assume the latter have uniform quality, mass production and similar characteristics.[1] We also assume that SFSCs are the main (say the only) form of distribution used to sell local production which can be purchased through two types of channels: a direct-to-consumer channel, where consumers come into direct contact with the producer to buy the good, and a direct-to-retailer channel, where an intermediary buys the product from the producer and resells it to consumers.[2] Conventional goods can be purchased through a long food supply chain (hereafter LFSC) channel, such as in supermarkets, large-scale retailers or grocery stores. For simplicity, we shall consider the direct-to-retailer sector to be composed of identical

[1]This assumption is particularly justified in developed economies, as we consider in this paper, where these characteristics are prevalent. Developed economies largely depend on global supply chains that prioritize standardization in food production to facilitate international trade and are characterised by advanced industrial and logistical capabilities that enable the production of goods with uniform quality and similar characteristics.

[2]Notice that there are only two possible SFSC channels because, as defined by EU Reg. 1305/13, a short supply chain is *"a supply chain involving no more than one intermediary between farmer and consumer"*, so there can be no further intermediaries, see European Commission (2016).

intermediaries that play a key role in bridging producers and consumers and supporting the growth of local economies. This allows us to clearly distinguish the short and the long food supply chains in terms of selling: the former sells products produced locally while the latter sells conventional goods not produced at the scale of the local economy. Examples of local intermediaries include food hubs, local cooperatives, but also environmental organizations aimed at promoting the local economy or reducing the carbon footprint of food distribution.

Our point of inception is that some consumers are aware of locally sourced food and are willing to pay more for local over non-local food (Onozaka and McFadden, 2011, Printezis and Grebitus, 2018). This awareness can be driven by cultural values such as supporting local economies, reducing the food system's environmental impact or supporting local identity and traditions. Previous studies have already analysed the determinants of consumers' preferences for local food, such as the perception of higher quality, concerns for local farmers, or contributing to the local economy (Darby et al., 2008; Dentoni et al., 2009; Toler et al., 2009). This is in line with the empirical evidence in Europe. For instance, a 2011 Eurobarometer survey of 26713 EU citizens, (European Commission, 2011), reveals that more than half of respondents totally agree that the EU should promote local markets and distribution channels to improve the availability of local agricultural products and also recognise the advantages of purchasing products directly from local farms. Moreover, a 2019 Eurobarometer survey (European Commission, 2019) concludes that the most important factors for Europeans when buying food are where the food comes from (53%).

Following the main insights of these studies and European surveys, we consider an economy with two types of consumers: those who embrace a sustainable food culture and prefer to consume locally sourced products and those who view local and conventional products as equal in utility. A sustainable food culture, indeed, relies on various factors, including environmental consciousness and awareness of local production. These factors influence broader household behaviour practices also affecting food choices within the household such as purchasing food from local farmers' markets or local hubs, and minimizing the purchase of conventional goods typically available in the LFSC. Sustainability values are often transmitted through socialization within families. For instance, families prioritizing sustainability often encourage practices like reducing food waste, supporting environmentally friendly farming methods or opting for seasonal production. Consumer behaviour studies clearly show that that food socialisation is a dynamic process (Hartmann et al., 2014) in which the family shapes children's lifelong food consumption (Kharuhayothin and Kerrane, 2018) and where intergenerational transferences are significant in shaping (un)sustainable food consumption throughout life (Carrigan et al., 2023).

In the economic literature, a powerful tool to describe the dynamics evolution of cultural traits across generations is the model of cultural transmission developed by Bisin and Verdier (2001), in which parents can decide the level of socialization for their children, driven by paternalistic preferences for desired traits. This cultural approach has been applied to several topics in the economics literature, such as trust and social capital (Francois and Zabojnik, 2005, Della Lena et al., 2023), family dynamics (Bisin and Verdier, 2000, Bisin et al., 2004, Hiller et al., 2023), religious norms (Seror, 2018), gender roles (Baudin and Hiller, 2019, Hiller et al., 2023), political ideology Melindi-Ghidi, 2012, among others. See Bisin and Verdier (2011, 2023) for a complete literature review. This methodology applies to environmental values as well (Bezin, 2015, 2019, Litina et al., 2016, Besley and Persson, 2019, Melindi-Ghidi et al., 2020). This article makes a methodological contribution to this literature in two directions: first, it concentrates on the interaction between sustainable food culture and the supply chain, second, by extending the standard framework to include, alongside the heterogeneity of preferences, a complete heterogeneity of incomes. Unlike previous contributions (see, for example, Tabellini, 2008 Doepke and Zilibotti, 2017), income heterogeneity is not restricted to two classes (rich and poor) but the income distribution can be a generic continuous distribution with density f. In our model, behaviour varies at each income level, and the overall effect on the evolution of preferences is obtained by aggregating the contributions of each group through a weighted integral. We also introduce a continuum of retailers, who acquire local products from producers and sell them to consumers. The number of retailers will be determined endogenously, based on market dynamics. In this framework, we study the interaction between the supply chain and the preference of consumers for locally sourced products. We study the implications that this interaction can have for developing effective public policies to promote a sustainable food culture.

Additionally, our paper also contributes to the literature on SFSC (see Jia et al., 2024 for a recent literature review), primarily addressing supply chain impacts on economic development (Richards et al., 2017), empowerment of small-scale producers (Abbate et al., 2023) and reducing environmental footprints (Starobin, 2021), but neglecting their role in influencing and interacting with consumers' preferences. Our paper fills this gap by considering sustainable food culture as a cultural value and studying how the supply chain shapes consumption behaviours and cultural dynamics to improve sustainability, ultimately offering insights into policy interventions in achieving sustainable development goals.

The paper is organized as follows: Section 2 introduces the setting and the theoretical model, Section 3 describes its dynamics and long-run behaviour in terms of income distribution and Section 4 discusses two extensions of the model. Section 5 explores the policy implications. Section 6 concludes. Technical proofs are provided in the Appendix.

2 The model

As discussed in the introduction, there exist two versions of the same good: a locally and a non-locally produced good. The locally produced good can be bought through two SFSCs: a direct-to-consumer (hereafter DTC) channel, where consumers purchase directly from the producer, and a direct-to-retailer (hereafter DTR) channel, where an intermediary buys from the producer and resells to consumers. In contrast, non-locally sourced "or conventional goods" are only sold through LFSC, such as supermarkets or large retailers.

There is a cost associated with the purchase of goods for consumers. It is reasonable to assume that the monetary (e.g., transportation, accessibility) and non-monetary (e.g. time, effort) costs of accessing large-scale distribution c^c are lower than those of accessing the DTR channel c^r. For the same reasons, it is also reasonable to assume that the latter cost is lower than the cost of directly contacting the producer c^p through the DTC channel due to the cost associated with accessibility and time. For simplicity, we assume $c^c = 0$ so that:

$$0 = c^c < c^r < c^p. \tag{1}$$

The DTR channel involves intermediaries who typically add a mark-up to cover a series of costs (salaries, transportation, sales locations, and so on). Thus, we assume that the price of the locally produced good in the DTR channel, p_l^r, is higher than that in the DTC channel p_l^p:

$$p_l^p < p_l^r.$$

We could also reasonably assume that the price of the conventional good p_c, is lower than that of the locally sourced good. For example, factors such as economies of scale, purchasing power due to bulk buying, or efficient logistics networks can effectively reduce selling costs for large retailers. In contrast, the DTC sales model requires high transaction costs and producers have the autonomy to establish pricing structures for their products, potentially resulting in a premium compared to prices observed within longer supply chains.[3] However, as we will see later, p_c does not

[3]This assumption is also in line with consumers' perceptions about food prices in the SFSC: evidence suggests that the main reason for not purchasing in SFSCs is the higher price (see Enthoven and Van den Broeck, 2021; Wang et al., 2022). Moreover, de Roest et al., 2018 observe that the

necessarily need to be lower than p_l^r and p_l^p in our theory. In fact, for our results, it is sufficient that p_c is not too much higher than the locally produced good. See (2) for details.

2.1 Consumers

In the economy, there is a continuum of consumers with a total mass of 1 differing in terms of food preferences: the consumers with a sustainable food culture who are sensitive to the consumption of local products ("local consumers") and those for whom the utility derived from consuming one unit of a local good is exactly equivalent to the utility derived from consuming one unit of a conventional good ("standard consumers"). To indicate these two groups, particularly in the figures, we will respectively use the abbreviations 'l-agent' and 's-agent'. In the following, we will denote by q_t the share of the population that is of l-type at time t and, consequently, by $(1 - q_t)$ the share of the population that is not.

The utility structure of the two types of agents is the same and is represented by a concave function u of the quantity Q of goods consumed. However, to model the distinction between the two types, we assume that local consumers experience a non-pecuniary psychological decrease in utility, denoted as $\gamma > 0$, when consuming a non-local good, while the others are indifferent between the two types of goods.

At every period of time, there is the same income distribution with cumulative distribution function $F(R)$ and density function $f(R)$ over the support $R \in (R_{min}, R_{max})$. Consumers allocate their income R to one of two goods. Specifically, the quantity Q purchased is given by $Q = \frac{R}{p_c}$ if they choose the conventional good, $Q = \frac{R-c^p}{p_l^p}$ if they purchase the local good through the DTC channel, and $Q = \frac{R-c^r}{p_l^r}$ if they purchase the local good through the DTR channel. Specifying u as the logarithm, the resulting utilities are summarized in Table 1.

type of product sold directly by producers to consumers can have a label, such as organic or IGP, and thus be of high quality compared to the goods sold in large retailers' channels.

Utility	Consumption of local good, DTC channel	Consumption of local good, DTR channel	Consumption of conventional good
Local consumer with income R	$\ln\left(\frac{R-c^p}{p_l^p}\right)$	$\ln\left(\frac{R-c^r}{p_l^r}\right)$	$\ln\left(\frac{R}{p_c}\right)-\gamma$
Standard Consumer with income R	$\ln\left(\frac{R-c^p}{p_l^p}\right)$	$\ln\left(\frac{R-c^r}{p_l^r}\right)$	$\ln\left(\frac{R}{p_c}\right)$

Table 1: Utility values for local and standard consumers depending on their income R and the choice of the local or conventional goods

As previously argued, one can expect the price of the conventional good to be lower than the local good. However, a less stringent assumption is required for our analysis:

$$\frac{R}{p_c} > \max\left\{\frac{R-c^r}{p_l^r}, \frac{R-c^p}{p_l^p}\right\} \tag{2}$$

Notice that this relation is easily satisfied for all $p_c < \min\{p_l^p, p_l^r\}$.

The agents' behaviours are described in the following Lemma.

LEMMA 1 *Under (1) and (2), for all level of income R, the standard consumers choose the conventional good. Moreover, there exist three income thresholds R_A, R_B, R_C, defined in Appendix A.1 (see (17), (18), (19)) , such that*

(i) The local consumers choose the DTR-locally produced good over the conventional good if and only if $R > R_A$;

(ii) The local consumers choose the DTC-locally produced good over the conventional good if and only if $R > R_B$;

(iii) The local consumers choose the DTR-locally produced good over the DTC-locally produced good if and only if $R < R_C$.

Proof. See Appendix A.1. □

As preferences derive from a utility function, they are transitive. Thus, not all orderings of the thresholds make sense: it is straightforward to observe that only two of them are possible: $R_C < R_B < R_A$, which is not very interesting for our research question because no one would buy from the DTR channel, and $R_A < R_B < R_C$, which is the interesting case because consumers buy goods in all possible channels. Therefore, we assume the following ordering:

Assumption 1 $R_{min} < R_A < R_B < R_C < R_{max}$.

Under Assumption 1, a local agent with income R will consume the conventional good if their income is sufficiently low ($R < R_A$). If the income falls within a medium range ($R_A < R < R_C$), she will choose the locally produced good from the retailer. Finally, if the agent has a high income ($R > R_C$), she will prefer the locally produced goods directly from the producer. [4] Conversely, as already discussed, the standard consumer will always choose the standard good.

In Figure 1, we illustrate, through a numerical example, the utility obtained by different agents as their income varies.[5] The standard agents (in blue) have a smoother utility curve because, as income changes, their behaviour remains consistent: they continue to purchase the maximum possible amount of the conventional good. Conversely, the two regime shifts (highlighted by the labels at the bottom) corresponding to R_A and R_C are present for the consumer with the sustainable food culture. Note that the utility level of the standard agent is higher because his utility function does not include the potential utility loss γ that affects the consumer with the sustainable food culture when choosing to consume the conventional good.

[4] We can safely claim that access to fresh and potentially locally produced food is predominantly reserved for higher-income households, due to financial means and the access to networks that facilitate the purchase of local products. Indeed, food insecurity has economic root causes (Drewnowski, 2022). Along these lines, a study on socio-economic disparities in the diet of French children and adolescents (Drouillet-Pinard et al., 2017) shows that children from higher-income households tend to have better diet quality, which often includes a higher intake of fresh and possibly locally sourced foods.

[5] We use the following parametrization: $p_c = 1$, $p_l^p = 1.5$, $p_l^r = 2$, $c^r = 0.5$, $c^p = 1.25$, $\gamma = \ln(4)$, so that $R_A = 1$, $R_B = 2$, $R_C = 3.5$).

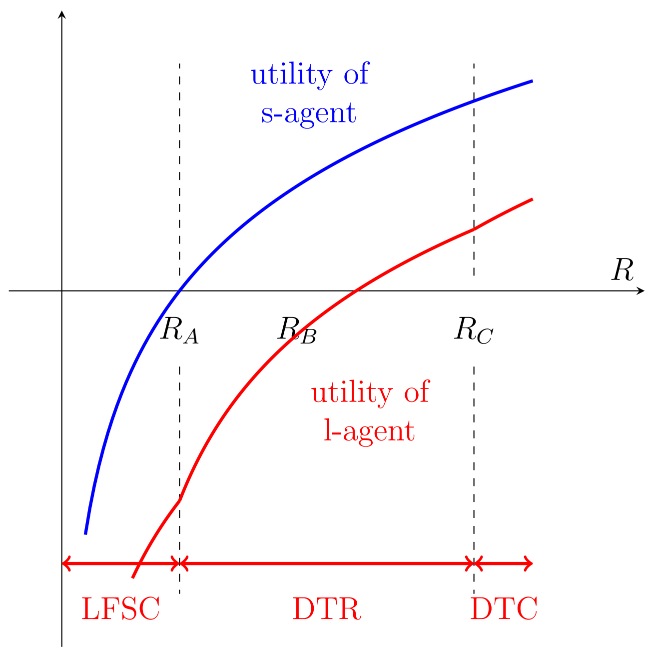

Figure 1: Utility of the standard and of the sustainable agent

2.2 The retailers

We consider a continuum of retailers with a mass n_t, which will be determined endogenously. The retailers are identical and purchase the local product at the price p_l^p, reselling it at a price p_l^r. The role of retailers is to facilitate the connection between producers and consumers, promoting local economies. Typical examples are food hubs, small grocery shops, local cooperatives but also environmental associations to promote the local economy or reduce the carbon footprint associated with food distribution. We follow Francois and Zabojnik (2005) assuming a perfectly competitive market where retailers can enter and exit quickly relative to the speed at which individuals' preferences change. Put differently, we consider that the number of retailers is determined by the following non-profit condition and that they adjust instantaneously to always be in equilibrium:

$$0 = -S + \frac{p_l^r - p_l^p}{n_t} \left(F(R_C) - F(R_A) \right) q_t \tag{3}$$

where S represents the fixed service costs (salaries, rents, etc.), and $(F(R_C) - F(R_A)) \cdot q_t$ is the total demand for the local good which is divided by n_t to obtain the individual demand per retailer.

2.3 The socialization process

As discussed in the introduction, individuals differ in their preference for the consumption of local products: some agents embrace a sustainable food culture and prefer locally sourced products, while others are indifferent between local and standard goods. Like other cultural traits, the sustainable food culture is shaped through a stochastic socialisation process within the family and across generations. Following the seminal work of Bisin and Verdier (2001), we explain how individual traits are determined, assuming that the total population is stationary and of size one. Individuals exhibit a form of myopia known as imperfect empathy, which implies that parents desire their children to embody characteristics similar to their own, as they assess their children's future welfare based on their own preferences. We will consistently assume that parents evaluate their children's future consumption decisions - whether to consume local or conventional goods - using their current preferences and revenue, even though these decisions will depend on the children's future preferences and income.

We illustrate this point in Figure 2, where we show how the perceived utility loss of the father varies as income changes if the child has a trait different from his own. In the left part of the figure, we consider the case of the s-type (standard) father. If the income is below R_A, the utility loss is zero because the child's behaviour (buying the conventional good) will be the same as that of a standard consumer. However, when a potential child with the local trait has an income above R_A and begins to forgo some of the consumer goods to prioritize quality (in terms of local production), there is a sudden increase in the difference between the utility perceived by the child and that perceived by the father. In the right part, we symmetrically show the utility driven by the choices of a standard child from the perspective of a father with the local trait. Similarly, in this case (and again because for incomes below R_A both traits behave in the same way), for lower incomes, the utility loss is zero. However, when the income is higher, and the father chooses the short supply chain unlike the child, a difference arises between the utility of the child and that perceived by the father. The greater these differences, the stronger the father's incentive to invest in educating the child to adopt their own trait.

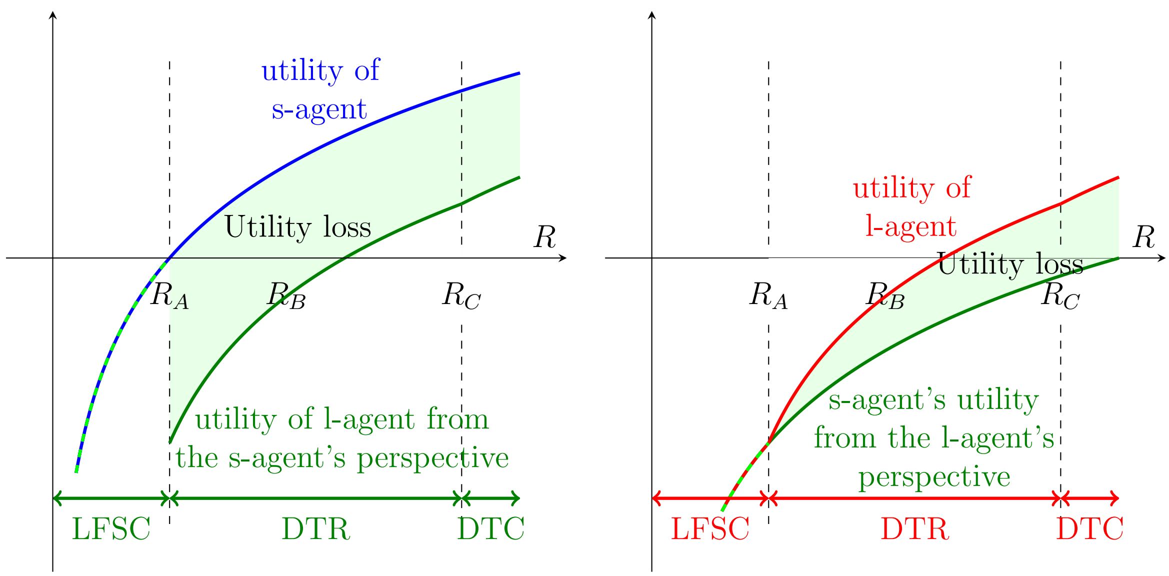

Figure 2: Utility loss according to the standard father if the child has the sustainable trait instead of the standard trait (left) and utility loss according to the sustainable father if the child has the standard trait instead of the sustainable trait (right).

When parents make decisions regarding their children's education, they do not know what their descendants' future income will be. More precisely, parents educate their children to have the same preferences as themselves by making certain socialization efforts. We define by $\tau^i(R)$, with $i \in \{l, s\}$ the probability of successfully transmitting their preferences i for parents of type i with income R. As better described below, we suppose that the effort to achieve a certain probability $\tau^i(R)$ of transmitting the trait has a certain (generalized) cost $C(\tau^i(R))$. We also assume that if the parent fails to transmit their own character to the child (i.e., with a probability of $1-\tau_t^i(R)$), an indirect socialization mechanism will intervene. In this case, the children's preferences will be shaped by imitating a random adult in society. So the probability that the child of a local consumer (type l) will have preferences of type l [respectively s] is

$$\pi_t^{ll}(R) = \tau_t^l(R) + (1-\tau_t^l(R))q_t \qquad \text{[respectively } \pi_t^{ls}(R) = (1-\tau_t^l(R))(1-q_t)\text{]} \quad (4)$$

while the probability that the child of a standard consumer (type s) has preferences of type l [respectively s] is

$$\pi_t^{sl}(R) = (1-\tau_t^s(R))q_t \qquad \text{[respectively } \pi_t^{ss}(R) = \tau_t^s(R) + (1-\tau_t^s(R))(1-q_t)\text{].} \quad (5)$$

Thus, aggregating the probabilities of all agents we have that the sustainable preferences (q_t) evolve as follows:

$$q_{t+1} = q_t \int_{R_{min}}^{R_{max}} \pi_t^{ll}(R) f(R) dR + (1-q_t) \int_{R_{min}}^{R_{max}} \pi_t^{sl}(R) f(R) dR. \quad (6)$$

Using (4) and (5) we can derive the counterpart of the typical dynamic equation of cultural transmission models:

$$q_{t+1} = q_t + q_t(1-q_t) \int_{R_{min}}^{R_{max}} \Big(\tau_t^l(R) - \tau_t^s(R)\Big) f(R) dR. \quad (7)$$

We now describe the effort choice of the parents. We suppose that the parent with preferences $i \in \{l, s\}$ and income R acts to maximize a target that contains both the expected utility of the child (calculated using the preferences of the parent, as explained above) and the cost $C(\tau_t^i(R))$ for socialization. The target has then the following form:

$$\max_{\tau_t^i(R)} \left(\pi_t^{ii}(R) u^{ii}(R) + \pi_t^{ij}(R) u^{ij}(R) - C(\tau_t^i(R))\right), \quad (8)$$

where $C(\tau_t^i)$ denotes the socialization cost function, π_t^{ii} and π_t^{ij} are given by (4)-(5) and $u^{ii}(R)$ [respectively $u^{ij}(R)$] is the utility derived by the consumption choice of an individual (the child) of type i [respectively j] evaluated by an individual of type i. As it is standard in this literature, we assume a quadratic cost function, that is

$$C(\tau) = \frac{\tau^2}{2}.$$

We look now at the behaviour of the agents in terms of socialization choices for all the six types of agents we have in the model depending both on the sustainable food culture and the level of income. To avoid making the description overly cumbersome with mathematical formulas, we relegate them in Appendix A.2.

Figure 2 suggests that for relatively low incomes agents (low but still higher than R_A), the utility loss perceived by a parent with a child of a different trait is greater for s-type individuals than for l-type individuals and that this situation may reverse for higher incomes. We can expect this difference to lead to consistent behaviour in terms of effort. Indeed we have the following result:

PROPOSITION 1 *Suppose that (1) and (2) hold, along with Assumptions 1. Then $\tau^i(R)$ are continuous function on $[R_A, R_{max}]$. Moreover $\tau^l(R)$ is an increasing function of R, while $\tau^s(R)$ is a decreasing function of R.*

Proof. See Appendix A.3. □

This result tells us that wealthy l-type individuals put more effort into educating their children in the local trait compared to poorer l-type individuals, while the opposite is true for s-type individuals: among them, those with relatively lower incomes (but still higher than R_A) put more effort into educating their children in the standard trait. This result has several consequences that will be highlighted in the subsequent analysis.

3 The dynamics of the model and long-run behavior

As in standard evolutionary models, we will concentrate on the continuous time limit version of the replicator dynamics (7):

$$\frac{dq}{dt} = q(t)(1-q(t)) \int_{R_{min}}^{R_{max}} \Big(\tau_t^l(R) - \tau_t^s(R)\Big) f(R)dR. \tag{9}$$

The integrand can be written in explicit way (see Appendix A.2) and we get the following results.

Proposition 2 *Suppose that (1) and (2) are satisfied together with Assumptions 1. The dynamics of $q(t)$ is described by the following dynamical system*

$$\begin{aligned}\frac{dq}{dt} = q(t)(1-q(t))\Bigg\{ &-\gamma q_t \int_{R_A}^{R_{max}} f(R)dR \\ &+ \int_{R_A}^{R_C} (\gamma - \ln(R) + \ln(p_c) + \ln(R-c^r) - \ln(p_l^r))\, f(R)dR \\ &+ \int_{R_C}^{R_{max}} (\gamma - \ln(R) + \ln(p_c) + \ln(R-c^p) - \ln(p_l^p))\, f(R)dR \Bigg\},\end{aligned} \tag{10}$$

The system has three steady states: the extremal points 0 *and* 1 *and :*

$$\begin{aligned}\bar{q}_r := 1 + \frac{1}{(1-F(R_A))\gamma} \times \Bigg[&-\ln\left(\frac{p_l^r}{p_c}\right)(F(R_C) - F(R_A)) + \int_{R_A}^{R_C} \ln\left(\frac{R-c^r}{R}\right) f(R)dR \\ &- \ln\left(\frac{p_l^p}{p_c}\right)(F(1) - F(R_C)) + \int_{R_C}^{R_{max}} \ln\left(\frac{R-c^p}{R}\right) f(R)dR.\end{aligned} \tag{11}$$

with $f(R)$ the density of $F(R)$. If $\bar{q}_r \in (0,1)$ then 0 *and* 1 *are unstable steady states while $\bar{q}_r$ is the unique globally asymptotically stable steady state.*

Proof. See Appendix A.3. □

In Figure 3, we observe the coupled dynamics of the system: the x-axis represents the value of $q(t)$, while the y-axis represents $n(t)$, the number (or mass) of retailers, which is related to $q(t)$ through equation (3). The graph highlights the three possible steady states of the system: two at the extremes and one internal, the point $(\bar{q}_r, \bar{n}_r)$. The black arrows indicate the direction of the joint evolution of the system which, as prescribed by Proposition 2 converges in the long-run to the point $(\bar{q}_r, \bar{n}_r)$.[6]

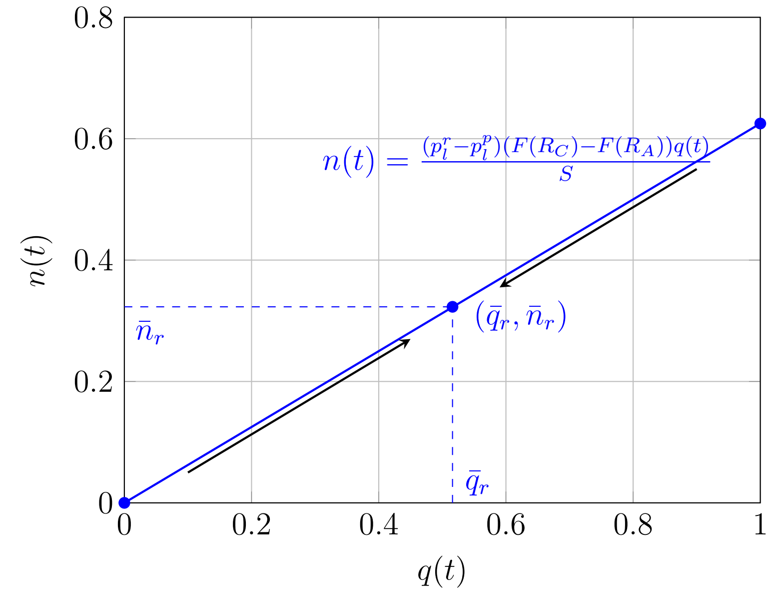

Figure 3: Plot of the joint dynamics of $q(t)$ and the number of retailers $n(t)$ along the equilibrium path of the system.

A final observation follows as a corollary of Proposition 1 and 2: if the income distribution shifts in such a way that no one becomes poorer, the steady-state $\bar{q}_r$ will increase.

Corollary 1 *Suppose that (1) and (2) hold, along with Assumptions 1. Suppose we have two cumulative income distributions F_1 and F_2 such that $F_2 < F_1$. Denoting by $\bar{q}_r^1$ the internal steady state related to F_1 and by $\bar{q}_r^2$ the internal steady state related to F_2, then:*

$$\bar{q}_r^1 < \bar{q}_r^2$$

Moreover, the share of income allocated to the local good is higher with the distribution F_2.

Proof. See Appendix A.3. □

[6] We use the following parametrization: $p_c = 1$, $p_l^p = 1.5$, $p_l^r = 2$, $R_A = 1$, $R_C = 3.5$, $S = 2$, and $f(R) = \frac{1}{4}\chi_{[0,4]}$. The point $(\bar{q}_r, \bar{n}_r) \approx (0.516, 0.323)$ is the equilibrium towards which the system converges.

4 Extensions of the model

4.1 The role of retailers

To understand the role of the DTR channel, we examine the same theoretical model, excluding retailers from the short-food supply chain. In such case, the threshold R_B introduced in (18) determines the income level that splits the population into two groups: agents with income $R > R_B$ buying the local product, while agents with income $R < R_B$ do not. Using the same argument as in Subsection 2.3 and in Section 3, we derive the following result:

PROPOSITION 3 *Suppose that (1) and (2) hold, along with Assumptions 1. The dynamics without retailers can be written as follows:*

$$\frac{dq}{dt} = q(t)(1-q(t))(\tau_t^l - \tau_t^c)$$
$$= q(t)(1-q(t))\Bigg\{F(R_B)(0-0) + \int_{R_B}^{1}\Bigg((1-q(t))\left(\ln\left(\frac{R-c^p}{p_l^p}\right) - \left(\ln\left(\frac{R}{p_c}\right) - \gamma\right)\right)$$
$$-q(t)\left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^p}{p_l^p}\right)\right)\Bigg) f(R)\,dR\Bigg\} \quad (12)$$

The system has three steady states: the extreme points 0 *and* 1 *and:*

$$\bar{q}_n = 1 + \frac{1}{(1-F(R_B))\gamma} \times \left[-\ln\left(\frac{p_l^p}{p_c}\right)(F(1) - F(R_B)) + \int_{R_B}^{1} \ln\left(\frac{R-c^p}{R}\right) f(R)\,dR\right] \quad (13)$$

If $\bar{q}_n \in (0,1)$, then 0 *and* 1 *are unstable steady states, while $\bar{q}_n$ is the unique globally asymptotically stable steady state without retailers.*

Proof. This can be proved using the same arguments as those used to prove Proposition 2 (see Appendix A.3 for the proof), but in a simpler case. □

How do the steady states compare between an economy with retailers and one without retailers? The first key result is as follows: in a world with retailers, a greater number of agents purchase the local product in the stable steady state (and, in fact, at every point in time). This is formally articulated in the following proposition.

PROPOSITION 4 *Suppose that (1) and (2) hold, along with Assumptions 1. Then the number of agents who buy the local good is higher in the steady state with retailers than in the steady state without retailers.*

Proof. See Appendix A.3. □

This result is quite intuitive but reflects a real-world phenomenon: the easier the access to local products, the greater the consumption of local goods. Its importance lies in the fact that, as highlighted in the introduction, the SFSC plays a vital role in promoting sustainability.

However, having a food system with retailers does not necessarily increase the equilibrium value of the non-trivial steady-state. Put differently, understanding whether q_n is greater or smaller than q_r is complicated to assess, and there is no definitive answer because it depends on both the values of various parameters and the shape of the income distribution. However, we can make some observations in line with the discussion we had regarding Proposition 1. Figure 4 presents the scenario without retailers. Compared to Figure 2, we can observe that for incomes between R_{min} and R_A, the socialization effort does not change. However, for income between R_A and R_C, the socialization effort does change. More precisely, when $R > R_A$ s-type agents increase their effort but the difference becomes progressively smaller for larger R and is zero for $R = R_C$. For incomes close to R_B the effort of l-type agents increases significantly when we introduce retailers in the model, while it decreases to zero when R goes to R_A or R_C. Finally, for incomes larger than R_{max} nothing changes.

These observations imply that the overall effect of transitioning from a situation without retailers to one with retailers does not have the same impact (given equal parameters) on the steady-state level of $\bar{q}$, depending on the income distribution of the economy. In particular, $\bar{q}$ is likely to increase more significantly in wealthier societies, making the spread of retailers especially effective in enhancing the prevalence of the local trait. Consequently, the spread of retailers is especially beneficial in promoting the sustainable trait in economies where consumers are more likely to support and afford locally produced goods.

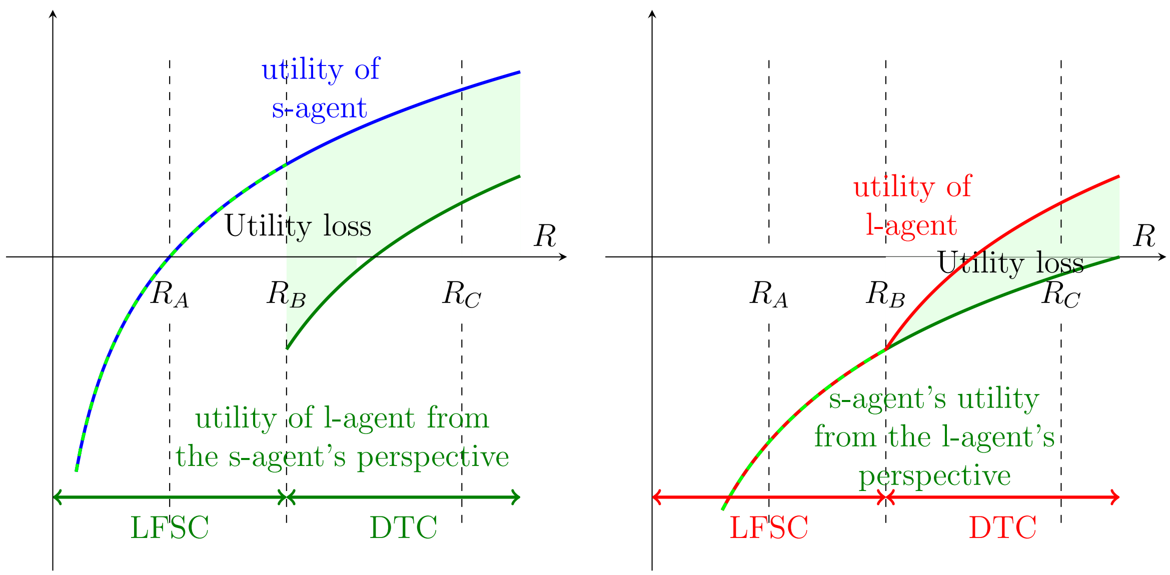

Figure 4: The model without DTR channel: utility loss according to the standard father if the child has the sustainable trait instead of the standard trait (left) and utility loss according to the sustainable father if the child has the standard trait instead of the sustainable trait (right).

4.2 The zero social mobility case

So far we have examined a polar case of perfect social mobility in which the income of the child is completely independent of the income of the parent. We now turn to the opposite polar case in which there is zero social mobility, meaning that the child's income is exactly equal to the parent's income. In this case, the process of trait accumulation q_t is specific to each income level. We denote by $q_t(R)$ the share of the subpopulation with income R and sustainable trait.

To simplify the analysis, we will also assume that social classes are perfectly segregated so that the indirect socialization mechanism occurs only among people with the same income. In this way, the counterparts of equations (4) and (5) are written in terms of $q_t(R)$ instead of q_t, and we have a different evolution for each income level R.[7] Using the same reasoning as before, we get that $q_t(R)$ evolves according to the following equation:

$$q_{t+1}(R) = q_t(R) + q_t(R)(1 - q_t(R))\Big(\tau_t^l(R) - \tau_t^s(R)\Big). \tag{14}$$

We claim the following counterpart to Proposition 2.

PROPOSITION 5 *Suppose that (1) and (2) hold, along with Assumptions 1. Then, the model with zero social mobility and perfect segregation predicts:*

(i) If $R < R_A$, then

$$\frac{dq(t,R)}{dt} = 0$$

The trajectories are constant.

(ii) If $R \in (R_A, R_C)$, then

$$\frac{dq(t,R)}{dt} = q(t,R)(1-q(t,R))\Bigg((1-q_t)\left(\ln\left(\frac{R-c^r}{p_l^r}\right) - \left(\ln\left(\frac{R}{p_c}\right) - \gamma\right)\right) - q_t\left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^r}{p_l^r}\right)\right)\Bigg). \tag{15}$$

When

$$\bar{q}_m(R) := 1 + \frac{1}{\gamma}\left(\ln\left(\frac{R-c^r}{R}\right) + \ln\left(\frac{p_c}{p_l^r}\right)\right)$$

belongs to $(0,1)$, then 0 and 1 are unstable steady states, while $\bar{q}(R)$ is the unique globally asymptotically stable steady state.

(iii) If $R > R_C$, then

$$\frac{dq(t,R)}{dt} = q(t,R)(1-q(t,R))\Bigg((1-q_t)\left(\ln\left(\frac{R-c^p}{p_l^p}\right) - \left(\ln\left(\frac{R}{p_c}\right) - \gamma\right)\right) - q_t\left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^p}{p_l^p}\right)\right)\Bigg). \tag{16}$$

When

$$\bar{q}_M(R) := 1 + \frac{1}{\gamma}\left(\ln\left(\frac{R-c^p}{R}\right) + \ln\left(\frac{p_c}{p_l^p}\right)\right)$$

[7] Notice that in this scenario the evolution of the cultural trait occurs within each income class, so there is no need to aggregate by integrating over the entire set of income classes.

belongs to $(0, 1)$*, then 0 and 1 are unstable steady states, while* $\bar{q}(R)$ *is the unique globally asymptotically stable steady state.*

Proof. See Appendix A.3. □

Let us now compare the result of Proposition 2 with those of Proposition 5. We observe that for incomes below R_A, the dynamics of q_t remain constant, equal to the initial condition. For these incomes levels, the two results cannot be compared (the average long-term values for $q(t, R)$ for $R < R_A$ depend on the distribution of $q_0(R)$ and thus will sometimes be higher and sometimes lower than $\bar{q}_r$ found in Proposition 2). However, if we look at the average in the population with incomes above R_A (i.e., the population where, even in the model with zero social mobility, there is a dynamic of preferences), we find that the average value of $\bar{q}$ in the population converges to $\bar{q}_r$, the same value as in the model with perfect social mobility. This result serves as a robustness check for the results obtained earlier.

Corollary 2 *Suppose that (1) and (2) hold, along with Assumptions 1. For the model with zero social mobility, we have the following: as* $t \to \infty$*, the average* $\bar{q}$ *of the population with incomes above* R_A *converges to*

$$\frac{1}{1 - F(R_A)} \left(\int_{R_A}^{R_C} q_m(R) f(R)\, dR + \int_{R_C}^{R_{max}} q_M(R) f(R)\, dR \right) = \bar{q}_r$$

where $\bar{q}_r$ *is defined in (11).*

Proof. See Appendix A.3. □

5 Policy implications

In this section, we analyse the policy implications of our theoretical model. Given that the model allows us to observe the response to policies across various population categories based on their income levels, we will discuss how different segments of the population receive and react to the proposed policies.

First, we will discuss the possible introduction of a tax on the conventional product in its simplest form and in some potential variants. We will then explore how other redistributive policies could address some of the shortcomings of this tax.

5.1 Taxation of the conventional product

The taxation of the conventional good would result in an increase in the price of the non-local good by a factor corresponding to the tax rate. This is a well-known issue in the literature on carbon taxation, which, among other things, triggered the "yellow vests" movement in France a few years ago in a different context, driven by similar economic mechanisms: it disproportionately affects the poorer (see Douenne and Fabre, 2020, 2022). In our theory, this mechanism is particularly transparent.

In terms of trait dynamics, the introduction of the tax on conventional goods has a twofold effect: first, for the relatively poor population with incomes below R_A before and after taxation, there are no effects. Second, there is an effect on the group that changes category due to the shift in R_A caused by the tax: in this group, s-type agents will strongly mobilize (in terms of socialization effort to promote their trait) in response to the introduction of the tax. Beyond this relatively small group, for non-poor agents with incomes above R_A (both before and after taxation) the effect of the tax on sustainable trait promotion will be positive. Indeed, as seen from the perspective of local agents, the utility variation between consuming local or not will increase, and, at the same time, from the perspective of standard agents, the advantage of consuming non-local will decrease.

The outcome of taxation of standard goods will be strongly anti-redistributive, disproportionately affecting the poor, and its impact on the promotion of the local trait will depend on income distribution, with an uncertain but likely positive effect in most cases, except for particular distributions. The anti-redistributive effects can be partially balanced by integrating the tax with the redistribution of its proceeds, such as in a non-distortionary lump-sum tax context. However, the uncertain effects on the evolution of cultural traits would remain. The same would apply to policies that subsidize the local product through various taxation schemes. We thus conclude that these policies require careful consideration, as their effects on the promotion of sustainable traits may be uncertain but are likely to have negative socio-economic implications.

5.2 Redistributive Policy

A purely redistributive policy, in addition to equity effects that fall outside the scope of this study, can positively influence the dynamics of preferences for any given income distribution. The following proposition describes the main effect of a policy taxing the wealthier population and redistributing the proceeds to the poorer population.

PROPOSITION 6 *Suppose that (1) and (2) hold, along with Assumptions 1. Then, any progressive tax among the population with income above R_A has the effect of increasing $\bar{q}^r$. More precisely, any (small enough) transfer from individuals with income $R_1 > R_A$ to individuals with income R_2, where $R_A < R_2 < R_1$ pre- and after-transfer, increases $\bar{q}^r$.*

Proof. See Appendix A.3. □

The intuition behind this result is based on an observation formally reported in Proposition 1 and Lemma 2: as incomes rise, the difference between the effort of l-type agents and the effort of s-type agents increases, but this increase has diminishing marginal returns. For this reason, transferring resources from the wealthier to the poorer population promotes the sustainable trait. However, this is true for individuals with incomes above R_A, i.e., the population that can ”express” their preferences through local consumption. Thus, if policymakers aim to promote the sustainable trait within the population as a key driver of sustainable food system transformation, ensuring that the benefits of local food consumption are more widely accessible to all income groups, implementing redistribution policies would be crucial.

6 Conclusion

In this article, we developed a cultural model of sustainability in food consumption to examine the dynamics of consumer preferences for locally sourced goods. We considered the existence of short and long supply chains where local and conventional goods are sold, respectively. Assuming that some consumers are aware of the benefits of locally produced food and are willing to pay a premium for local products, we studied the critical role of short food supply chains in promoting sustainable behaviours in food consumption choices.

We extended the cultural transmission framework of Bisin and Verdier (2001) by incorporating income heterogeneity through a continuous distribution in a framework in which retailers supply local products. We examined the interaction between the supply chains and cultural factors to analyse the evolution of a sustainable culture in food choices, highlighting the potential implications for designing public policies to promote sustainability in the food system.

The implications of our model suggest that public policies aiming to promote sustainable consumption should consider the socio-economic diversity of the population. Supporting access to local goods through retailers and implementing progressive redistribution can help to develop environmentally friendly consumption practices without impacting low-income households.

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A Proofs

A.1 Agents' consumption choices

Proof of Lemma 1. We have that

(1) Using the preferences described in Table 1 (second line) one can easily see that, thanks to (2), the standard consumers always consume the conventional good independently of the revenue.

(2.i) Using the preferences described in Table 1 (first line) one can see that (a) the local consumers always prefer the DTR-locally produced good over the conventional good if $\frac{1}{p_c}e^{-\gamma} - \frac{1}{p_l^r} > 0$ and (b) they do so if and only if

$$R > R_A := \frac{c^r}{1 - \frac{p_l^r}{p_c}e^{-\gamma}} \qquad \text{when } \frac{1}{p_c}e^{-\gamma} - \frac{1}{p_l^r} < 0. \tag{17}$$

(2.ii) Using the preferences described in Table 1 (first line) one can see that (a) the local consumers always prefer the DTC-locally produced good over the conventional good if $\frac{1}{p_c}e^{-\gamma} - \frac{1}{p_l^p} > 0$ (b) they do so if and only if :

$$R > R_B := \frac{c^p}{1 - \frac{p_l^p}{p_c}e^{-\gamma}} \qquad \text{when } \frac{1}{p_c}e^{-\gamma} - \frac{1}{p_l^p} < 0. \tag{18}$$

(2.iii) Using the preferences described in Table 1 (first line) one can see that the local consumers prefer the DTR-locally produced good over the DTC-locally produced good if and only if :

$$R < R_C := \frac{c^p p_l^r - c^r p_l^p}{p_l^r - p_l^p}. \tag{19}$$

So we can conclude. □

A.2 Individual decisions in terms of socialization effort

We calculate here the socialization efforts of the parents in terms of their cultural traits and income as described in Subsection 2.3.

Following Table 1,

$$u^{ll}(R) = \max\left\{\ln\left(\frac{R-c^p}{p_l^p}\right), \ln\left(\frac{R-c^r}{p_l^r}\right), \ln\left(\frac{R}{p_c}\right)-\gamma\right\},\quad u^{ls}(R) = \ln\left(\frac{R}{p_c}\right)-\gamma$$

$$u^{sl}(R) = \max\left\{\ln\left(\frac{R-c^p}{p_l^p}\right), \ln\left(\frac{R-c^r}{p_l^r}\right), \ln\left(\frac{R}{p_c}\right)\right\},\quad u^{ss}(R) = \ln\left(\frac{R}{p_c}\right)$$

We now maximize the target

$$\max_{\tau_t^i(R)}\left(\pi_t^{ii}(R)u^{ii}(R) + \pi_t^{ij}(R)u^{ij}(R) - C(\tau_t^i(R))\right),$$

when

$$C(\tau) = \frac{\tau^2}{2}.$$

We get the following:

(i) Parents with sustainable food culture and low income (i.e. $R < R_A$). It is easy to see that choose $\tau_t^l = 0$.

(ii) Parents with sustainable food culture and medium income (i.e. $R_A < R < R_C$, remarque that this implies $\left(\ln\left(\frac{R-c^r}{p_l^r}\right) - \left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right) > 0$). They choose τ_t^l to maximize

$$(\tau_t^l + (1-\tau_t^l)q_t)\left(\ln\left(\frac{R-c^r}{p_l^r}\right)\right) + ((1-\tau_t^l) - (1-\tau_t^l)q_t)\left(\ln\left(\frac{R}{p^c}\right)-\gamma\right) - C(\tau_t^l)$$

So that , $\tau_t^l = (1-q_t)\left(\ln\left(\frac{R-c^r}{p_l^r}\right) - \left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right)$.

(iii) Parents with sustainable food culture and high income (i.e. $R > R_C$, remark that this implies $\left(\ln\left(\frac{R-c^p}{p_l^p}\right) - \left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right) > 0$). They choose τ_t^l to maximize

$$(\tau_t^l + (1-\tau_t^l)q_t)\left(\ln\left(\frac{R-c^p}{p_l^p}\right)\right)$$
$$+((1-\tau_t^l)-(1-\tau_t^l)q_t)\left(\ln\left(\frac{R}{p^c}\right)-\gamma\right)-C(\tau_t^l)$$

So, in this case, $\tau_t^l = (1-q_t)\left(\ln\left(\frac{R-c^p}{p_l^p}\right)-\left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right)$.

(iv) Parents without sustainable food culture and low income. They choose τ_t^s to maximize

$$(\tau_t^s + (1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R}{p^s}\right)\right)$$
$$+((1-\tau_t^s)-(1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R}{p^s}\right)\right)-C(\tau_t^s)$$

Thus, $\tau_t^s = 0$.

(v) Parents without sustainable food culture and medium income (i.e. $R_A < R < R_C$, observe that, thanks to (2) we have $\left(\ln\left(\frac{R}{p_c}\right)-\ln\left(\frac{R-c^r}{p_l^r}\right)\right) > 0$). They maximize

$$(\tau_t^s + (1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R}{p_c}\right)\right)$$
$$+((1-\tau_t^s)-(1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R-c^r}{p_l^r}\right)\right)-C(\tau_t^s)$$

So, in this case, $\tau_t^s = q_t\left(\ln\left(\frac{R}{p_c}\right)-\ln\left(\frac{R-c^r}{p_l^r}\right)\right)$.

(vi) Parents without sustainable food culture and high income (i.e. $R > R_C$, observe that, thanks to (2) we have$\left(\ln\left(\frac{R}{p_c}\right)-\ln\left(\frac{R-c^p}{p_l^p}\right)\right) > 0$). They maximize

$$(\tau_t^s + (1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R}{p_c}\right)\right)$$
$$+((1-\tau_t^s)-(1-\tau_t^s)(1-q_t))\left(\ln\left(\frac{R-c^p}{p_l^p}\right)\right)-C(\tau_t^s)$$

So, for them, $\tau_t^s = q_t \left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^p}{p_l^p}\right)\right)$.

A.3 Other proofs

Proof of Proposition 1. To verify the continuity of τ^i, we only need to check its continuity at R_C based on the expressions given in Appendix A.2 (in other points, they are simply sums and compositions of regular functions). More precisely, for $i = l$, we need to check that τ^l, as described in points (ii) and (iii), is continuous at R_C, but this follows directly from the definition of R_C. The same applies to the expressions for τ^s described in points (v) and (vi).

To verify the claims about increasing and decreasing behaviour, we just need to take the derivative of the efforts found in Subsection A.2. For agents with income lower than R_A, the effort is zero in both groups.

For agents endowed with a sustainable food culture and medium income, we have

$$\frac{d\tau_t^l(R)}{dR} = (1-q_t)\left(\frac{1}{R-c^r} - \frac{1}{R}\right) > 0.$$

For agents endowed with a sustainable food culture and high income, we have

$$\frac{d\tau_t^l(R)}{dR} = (1-q_t)\left(\frac{1}{R-c^p} - \frac{1}{R}\right) > 0.$$

For standard agents with medium income, we have

$$\frac{d\tau_t^s(R)}{dR} = q_t\left(\frac{1}{R} - \frac{1}{R-c^r}\right) < 0.$$

For standard agents with high income, we have

$$\frac{d\tau_t^s(R)}{dR} = q_t\left(\frac{1}{R} - \frac{1}{R-c^p}\right) < 0.$$

Therefore, putting everything together, for $R > R_A$, $\tau_t^i(R)$ is increasing if $i = l$ and decreasing if $i = s$. □

In fact, a bit more can be said about τ. We have the following lemma, which will be used in subsequent proofs:

LEMMA 2 *Suppose that (1) and (2) hold, along with Assumptions 1. Then the* *function*

$$\begin{cases} \psi\colon [R_A, R_{max}] \to \mathbb{R} \\ \psi\colon R \mapsto \tau^s(R) - \tau^l(R) \end{cases}$$

is continuous, decreasing and concave.

Proof. ψ is continuous and decreasing thanks to Proposition 1. We compute the second derivative of $\tau^s(R) - \tau^l(R)$:

$$\begin{aligned} \frac{d^2}{dR^2}(\tau^s(R) - \tau^l(R)) = (1-q_t)\left(-\frac{1}{(R-c_p)^2} + \frac{1}{R^2}\right) - q_t\left(-\frac{1}{R^2} + \frac{1}{(R-c_p)^2}\right) \\ = \left(-\frac{1}{(R-c_p)^2} + \frac{1}{R^2}\right) < 0 \quad (20) \end{aligned}$$

so ψ is concave. □

Proof of Proposition 2. Using the expressions found in of Appendix A.2 we have

$$\begin{aligned} &q_t(1-q_t)\int_{R_{min}}^{R_{max}} \left(\tau_t^l(R) - \tau_t^s(R)\right) f(R)dR = q_t(1-q_t)(\tau_t^l - \tau_t^c) = q_t(1-q_t)\Big\{F(R_A)(0-0) \\ &+\int_{R_A}^{R_C}\left((1-q_t)\left(\ln\left(\frac{R-c^r}{p_l^r}\right) - \left(\ln\left(\frac{R}{p_c}\right) - \gamma\right)\right) - q_t\left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^r}{p_l^r}\right)\right)\right) f(R)dR \\ &+\int_{R_C}^{R_{max}}\left((1-q_t)\left(\ln\left(\frac{R-c^p}{p_l^p}\right) - \left(\ln\left(\frac{R}{p_c}\right) - \gamma\right)\right) - q_t\left(\ln\left(\frac{R}{p_c}\right) - \ln\left(\frac{R-c^p}{p_l^p}\right)\right)\right) f(R)dR\Big\} \\ &= q_t(1-q_t)\Big\{-\gamma q_t\int_{R_A}^{R_{max}} f(R)dR + \int_{R_A}^{R_C}\left(\gamma - \ln(R) + \ln(p_c) + \ln(R-c^r) - \ln(p_l^r)\right) f(R)dR \\ &\qquad + \int_{R_C}^{R_{max}}\left(\gamma - \ln(R) + \ln(p_c) + \ln(R-c^p) - \ln(p_l^p)\right) f(R)dR\Big\}. \quad (21) \end{aligned}$$

From this expression, we can easily see that 0 and 1 are steady states. The term inside the curly brackets, although seemingly complicated, is of the form

$$-aq(t) + b$$

with a and b being two positive real numbers (note that b is positive thanks to (17), since the integral is computed for values $R > R_A$). It vanishes in $\bar{q}_r$ defined as

$$\bar{q}_r = \frac{1}{(1-F(R_A))\gamma} \times \Bigg[\left(\gamma + \ln\left(\frac{p_c}{p_l^r}\right)\right)(F(R_C) - F(R_A)) + \int_{R_A}^{R_C} \ln\left(\frac{R - c^r}{R}\right) f(R)dR$$
$$\left(\gamma + \ln\left(\frac{p_c}{p_l^p}\right)\right)(F(1) - F(R_C)) + \int_{R_C}^{1} \ln\left(\frac{R - c^p}{R}\right) f(R)dR\Bigg]$$
$$= 1 + \frac{1}{(1-F(R_A))\gamma} \times \Bigg[- \ln\left(\frac{p_l^r}{p_c}\right)(F(R_C) - F(R_A)) + \int_{R_A}^{R_C} \ln\left(\frac{R - c^r}{R}\right) f(R)dR$$
$$- \ln\left(\frac{p_l^p}{p_c}\right)(1 - F(R_C)) + \int_{R_C}^{R_{max}} \ln\left(\frac{R - c^p}{R}\right) f(R)dR. \quad (22)$$

The hypothesis $\bar{q}_r \in (0, 1)$ translates to $b/a < 1$. In this case, the right-hand side of the equation

$$\dot{q}(t) = q(t)(1 - q(t))(-aq(t) + b)$$

is positive for $q < \bar{q}_r$ and negative for $q > \bar{q}_r$, so $\bar{q}_r$ is asymptotically stable. □

Proof of Corollary 1. The claim follows from Proposition 1. Indeed, for a given level of q, when we increase the income of agents, the effort to transmit the cultural trait increases for local parents and decreases for standard parents. Therefore, for each level of q, the integrand in (9) is greater with the distribution F_2 than with the distribution F_1, meaning that the time derivative of $q(t)$ is greater, and thus the steady-state $\bar{q}_r^2$ will be larger than $\bar{q}_r^1$.

The total share of income used to purchase the local product is given, in the two cases, by

$$\bar{q}_r^1(1 - F_1(R_A))$$

and

$$\bar{q}_r^2(1 - F_2(R_A)).$$

Since both factors are larger in the second expression, the share of income used to purchase the local product is greater when we have F_2. Furthermore, since the total income of the population is also greater under distribution F_2, it follows that the total income spent on local goods is, a fortiori, higher as well. □

Proof of Proposition 4. We can compute the two quantities and subtract them. We get:

$$
\begin{aligned}
&(1-F(R_A))\bar{q}_r-(1-F(R_B))\bar{q}_n=F(R_B)-F(R_A)\\
&+\frac{1}{\gamma}\left[-\ln\left(\frac{p_l^r}{p_c}\right)(F(R_C)-F(R_A))-\ln\left(\frac{p_l^p}{p_c}\right)(1-F(R_C))+\ln\left(\frac{p_l^p}{p_c}\right)(1-F(R_B))\right]\\
&+\frac{1}{\gamma}\left[-\int_{R_B}^{R_C}\ln\left(\frac{R-c^p}{R}\right)f(R)dR+\int_{R_B}^{R_C}\ln\left(\frac{R-c^r}{R}\right)f(R)dR+\int_{R_A}^{R_B}\ln\left(\frac{R-c^r}{R}\right)f(R)dR\right]\\
&=F(R_B)-F(R_A)+\frac{1}{\gamma}\left[\ln\left(\frac{p_l^p}{p_l^r}\right)(F(R_C)-F(R_B))-\ln\left(\frac{p_l^r}{p_c}\right)(F(R_B)-F(R_A))\right]\\
&\qquad+\frac{1}{\gamma}\left[\int_{R_B}^{R_C}\ln\left(\frac{R-c^r}{R-c^p}\right)f(R)dR+\int_{R_A}^{R_B}\ln\left(\frac{R-c^r}{R}\right)f(R)dR\right]\\
&=\frac{1}{\gamma}\left[\int_{R_A}^{R_B}\gamma f(R)dR+\int_{R_A}^{R_B}\ln\left(\frac{R-c^r}{R}\right)f(R)dR-\ln\left(\frac{p_l^r}{p_c}\right)(F(R_B)-F(R_A))\right]\\
&\qquad+\frac{1}{\gamma}\left[\ln\left(\frac{p_l^p}{p_l^r}\right)(F(R_C)-F(R_B))+\int_{R_B}^{R_C}\ln\left(\frac{R-c^r}{R-c^p}\right)f(R)dR\right]\\
&\qquad=\frac{1}{\gamma}\left[\int_{R_A}^{R_B}\left(\gamma+\ln\left(\frac{R-c^r}{R}\right)-\ln\left(\frac{p_l^r}{p_c}\right)\right)f(R)dR\right]\\
&\qquad\qquad+\frac{1}{\gamma}\left[\int_{R_B}^{R_C}\left(\ln\left(\frac{R-c^r}{R-c^p}\right)+\ln\left(\frac{p_l^p}{p_l^r}\right)\right)f(R)dR\right] \qquad (23)
\end{aligned}
$$

and the two integrands are positive on their domain because of the definition of R_A and R_B. □

Proof of Proposition 5. Arguing in the same way as Subsection 2.3 we find that

- If $R < R_A$, then $\tau_t^l(R) = \tau_t^s(R) = 0$
- If $R \in (R_A, R_C)$, then

$$\tau_t^l = (1-q_t)\left(\ln\left(\frac{R-c^r}{p_l^r}\right)-\left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right)$$

  and

$$\tau_t^s = q_t\left(\ln\left(\frac{R}{p_c}\right)-\ln\left(\frac{R-c^r}{p_l^r}\right)\right).$$

- If $R > R_C$, then

$$\tau_t^l = (1-q_t)\left(\ln\left(\frac{R-c^p}{p_l^p}\right)-\left(\ln\left(\frac{R}{p_c}\right)-\gamma\right)\right)$$

and

$$\tau_t^s = q_t \left(\ln \left(\frac{R}{p_c} \right) - \ln \left(\frac{R - c^p}{p_l^p} \right) \right).$$

This gives the evolution of the continuous dynamics $q(t, R)$ that we describe in the claim. The proofs of the claim related to long-run behaviour follow as in the proof of Proposition 2. □

Proof of Corollary 2. One has just to compute the integral using the values given in Proposition 5. □

Proof of Proposition 6. The proof is a consequence of Lemma 2. In fact, the transfer of income has two effects (in terms of agents' efforts to maintain their trait and, consequently, in terms of the dynamics of q): (i) on the one hand, the wealthier population becomes poorer, and since the function $\tau^s(R)$ is decreasing and $\tau^l(R)$ is increasing, this increases the effort of standard agents in this population to promote their trait and reduces the effort of local agents to promote theirs; (ii) on the other hand, the poorer population becomes wealthier, with the opposite effect.

Since, as shown in Lemma 2, the function $\tau^s(R) - \tau^l(R)$ is decreasing and concave, the second effect is larger than the first, and thus we have the claim. □