MTT REPORT 32

The effectiveness of differentiated food taxes in promoting dietary quality and nutritional health: A review of the international and Finnish evidence

Xavier Irz and Jyrki Niemi

MTT

MTT REPORT 32

The effectiveness of differentiated food taxes in promoting dietary quality and nutritional health: A review of the international and Finnish evidence

Xavier Irz and Jyrki Niemi

ISBN 978-952-487-343-7
ISSN 1798-6419
http:// www.mtt.fi/mttraportti/pdf/mttraportti32.pdf

Auhtors: Xavier Irz, Jyrki Niemi
Distribution and sale: MTT, 31600 Jokioinen
Printing year: 2011
Cover picture: Pentti Hokkanen / Copyright: MTT

Kohdennettujen elintarvikeverojen tehokkuus terveellisen ruokavalion ja ravitsemusterveyden edistäjinä: Katsaus kansainvälisistä ja suomalaisista tutkimuksista saatuun näyttöön

Irz, Xavier ja Niemi, Jyrki
MTT Taloustutkimus, Latokartanonkaari 9, 00790 Helsinki, etunimi.sukunimi@mtt.fi

Yhteenveto

Monissa korkean tulotason maissa on alettu huolestua liikalihavuuden ja kroonisten sairauksien lisääntymisestä. Ratkaisuksi on ehdotettu kohdennettuja elintarvikeveroja ja -tukia, joiden avulla pyrittäisiin parantamaan ruokavalion laatua, pienentämään nautitun energian määrää ja vähentämään ruokavalioon liittyvien sairauksien taakkaa. Suomi liittyi yleisempään suuntaukseen ottamalla vuoden 2011 alussa käyttöön pienen makeisia, alkoholittomia juomia ja jäätelöä koskevan valmisteveron, mutta keskustelu siitä, tulisiko kansanterveyttä pyrkiä edistämään verotuksellisin keinoin, jatkuu edelleen. Tärkeitä, mutta toistaiseksi ratkaisemattomia kysymyksiä liittyy mm. veron muotoon (elintarvike- vai ravintoaineperustainen vero? valmistevero vai ad valorem -vero?) ja veron kattavuuteen eri tuoteryhmissä ja ravintoaineissa. Lisäksi kysymyksiä herättää se, tulisiko veroon yhdistää tukia, joilla kannustetaan terveellisen ruoan kulutukseen ja kompensoidaan mahdollisesti elintarviketeollisuudelle aiheutuvia kustannuksia. Halusimme tuoda panoksemme tähän keskusteluun tekemällä katsauksen kohdennettujen elintarvikeverojen teoreettiseen perustaan sekä niukkaan, mutta nopeasti lisääntyvään aihetta käsittelevään empiiriseen tutkimuskirjallisuuteen.

Kohdennettuja veroja voidaan perustella epäterveellisen ruokavalion ja siihen liittyvien sairauksien yhteiskunnalle aiheuttamilla suurilla kustannuksilla. Valitettavasti on käytännössä mahdotonta verottaa ainoastaan epäterveellisten ruokien liikakulutusta verottamatta samalla niiden kohtuullista kulutusta, vaikka tämä olisikin ihanteellinen ratkaisu. Lisäksi tutkimustulokset antavat viitteitä siitä, että kuluttajat eivät tee elintarvikkeita ja ruokavaliota koskevia valintojaan rationaalisesti. Tällöin veroilla voitaisiin korjata kulutuskäyttäytymisen ongelmia, esim. itsekurin puutetta. On kuitenkin tärkeää ottaa huomioon, että vero aiheuttaa kustannuksia sekä yksilöille että julkiselle sektorille, ja veroa voidaan pitää yhteiskunnan kannalta perusteltuna ainoastaan, mikäli sen hyödyt ovat suurempia kuin sen kustannukset. Tämä on empiirinen kysymys, joka on ratkaisevasti sidoksissa siihen, kuinka tehokkaasti kohdennetut verot pystyvät ohjaamaan kuluttajia terveellisempiin valintoihin. Suomessa tätä kysymystä on pohdittu vain kahdessa viimeaikaisessa tutkimuksessa, jotka ikävä kyllä päätyivät varsin erilaisiin johtopäätöksiin. Ainoastaan Kotakorpi ym. (2011) tukee ajatusta, että maltilliset kohdennetut verot voisivat saada aikaan merkittäviä parannuksia ravitsemusterveyteen. Toinen tutkimus (Irz, 2010) viittaa siihen, että nautitun energian määrään ja liikalihavuuteen ei pystyttäisi vaikuttamaan verolla, joka kohdistetaan runsaasti rasvaa ja sokeria sisältäviin elintarvikkeisiin, eivätkä veron vaikutukset ruokavalion laatuun olisi yksiselitteisiä.

Vaikka kohdennettujen verojen vaikutukseen liittyvä epäselvyys on valitettavaa, tilanne on hyvin tyypillinen muissakin maissa. Tämä viittaa siihen, että tähän asti sovelletut ekonometriset menetelmät ovat luonteeltaan liian rajoittuneita tämän tyyppisen tutkimusaiheen käsittelyyn. Suurin ongelma liittyy tuotteen hintajouston ja ristijouston täsmälliseen arviointiin sellaisessa tuotetason jaottelussa, joka perustuisi ravintonäkökohtiin taloudellisten näkökohtien sijaan. Kumpikaan suomalaisista tutkimuksista ei vaikuta aivan tyydyttävältä tässä suhteessa, ja siksi on vaikea väittää, että kohdennettujen elintarvikeverojen käyttöönotto Suomessa pohjautuisi tieteelliseen näyttöön. Vaikka alan kirjallisuus ei pysty esittämään yksiselitteisiä johtopäätöksiä, tekemämme katsaus nostaa esille muutamia tärkeitä havaintoja.

Ensinnäkin, elintarvikkeiden kohdennettujen verojen vaikutus ruokavalintoihin, ravinnonsaantiin ja terveyteen on monimutkainen yhtälö. Tietyn yksittäisen elintarvikkeen verotus vaikuttaa välillisesti koko ruokavalioon, mikä johtuu eri elintarvikkeiden monimutkaisista ja pääosin tuntemattomista keskinäisistä korvaavuus- ja täydentävyyssuhteista. Tällä havainnolla on käytännön merkitystä, sillä eräät tutkimukset

ovat osoittaneet, että tahattomien vaikutusten johdosta hyvää tarkoittavat verot mitä todennäköisimmin lisäävät ruokavalioon liittyvien sairauksien riskiä sen sijaan, että vähentäisivät sitä. Empiirisen tutkimuksen esiintuoma ruokavalintojen kompleksisuus on räikeässä ristiriidassa sen kanssa, kuinka kohdennetut verot yleensä esitetään suurelle yleisölle. Kohdennettujen verojen kohteena olevat elintarvikkeethan leimataan tyypillisesti ”roskaruoaksi” ja toteutuksessa luotetaan intuitiivisesti toimivalta tuntuvaan kysynnän lakiin.

Toiseksi, laajaan elintarvikevalikoimaan kohdennetut maltilliset verot eivät tutkimusten mukaan yleensä pysty muuttamaan käyttäytymistä tai kohentamaan ruokavalion laatua. Kotakorven ym. (2011) tutkimus on tästä poikkeus, mutta heidän tuloksensa pohjautuvat suurelta osin yksittäiseen muuttujan arvoon eli ”sokerin ja makeisten” kysynnän hintajoustoon. Kotakorven ym. tutkimuksessaan käyttämä kysynnän hintajousto on lisäksi kansainvälisesti verraten äärimmäisen korkea, mikä vaikuttaakin ratkaisevasti tutkimuksen lopputuloksiin. Näin ollen kyseinen tutkimus ei tarjoa vakuuttavaa pohjaa poliittisten ratkaisujen tekemiseen.

Kolmanneksi, yksikäsitteisten myönteisten muutosten aikaansaaminen ruokavalioon ja veropolitiikan tehokas kohdentaminen vaativat yleensä useiden verojen ja tukien yhdistelmää. Tehokkaan politiikan laatiminen edellyttää siten huolellista erilaisten vero- ja tukimallien vertailua siitä näkökulmasta, miten eri mallit vaikuttaisivat ruokavalioon ja terveyteen. Kun jokin malli on otettu käyttöön, sen vaikutuksia tulee seurata ja arvioida säännöllisesti, ja verokantoja ja verotettavien tuotteiden tai ravintoaineiden ryhmiä on tarvittaessa muutettava. Eräs tukien ja verojen yhdistelmän käytön lisäetu on siinä, että käytäntö lieventää epäilyksiä, että kohdennettujen elintarvikeverojen tarkoitus on lisätä pelkästään valtion tuloja kansanterveyden parantamisen sijaan.

Neljänneksi, tehokkaan kannustinjärjestelmän välineet on valjastettava mahdollisimman tehokkaasti edistämään kansanterveydellisiä tavoitteita. Jos terveyspolitiikan tavoitteena on esimerkiksi vähentää tiettyjen runsaasti energiaa mutta vähän hyödyllisiä ravintoaineita sisältävän ruoan (ns. tyhjien kalorien, esim. makeisten) kulutusta, yksinkertainen ja helposti hallinnoitava valmistevero on todennäköisesti tehokkaampi kuin ravintoainevero. Toisaalta, jos tavoitteena on vähentää tietyn ravintoaineen saantia, elintarvikkeiden vaihteleva verotus ravintosisällön perusteella on todennäköisesti tehokkaampi kuin samansuuruisena laajoille elintarvikeryhmille asetettu vero, koska tällöin elintarvikkeiden kuluttajat voivat korvata runsaasti verotettavaa ravintoainetta sisältävät tuotteet saman tuoteryhmän vähempisisältöisillä tuotteilla. Ravintoaineveroon liittyy myös se hyvä puoli, että se synnyttää elintarvikkeiden valmistajille kannustimen muokata tuotteitaan terveellisempään suuntaan. Viime kädessä eri malleja on kuitenkin verrattava siltä pohjalta, mitä tietyn terveysvaikutuksen saavuttaminen kullakin mallilla maksaa.

Viidenneksi, on pidettävä mielessä, että verotukselliset keinot vaikuttavat paitsi elintarvikkeiden kysyntään, myös niiden tarjontaan. Ei voida olettaa, että vero siirtyisi elintarvikeketjussa täysimääräisesti toimittajilta kuluttajille, vaan tämä asia on myös tutkittava empiirisesti.

Erityisesti Suomen verotusta pohdittaessa käynnissä olevan keskustelun tietopohjaksi olisi selvitettävä useita asioita:

- Mikäli halutaan löytää kustannustehokas ja vaikutuksiltaan tehokas veroratkaisu ja otetaan huomioon, kuinka vähän erilaisia verotuksellisia keinoja Suomessa on tähän mennessä tutkittu, on panostettava tutkimustyöhön, jolla pyritään yksilöimään sellaiset kannustinjärjestelmät, jotka pystyvät saamaan aikaan merkittäviä parannuksia kansanterveydessä pienimmillä mahdollisilla kustannuksilla. Mitä tulee nyt käynnissä olevaan poliittiseen keskusteluun, korostamme, että mikään toistaiseksi tehty tutkimus ei pysty valottamaan ravintoainepohjaisen veron (esim. sokeriveron) todellisia vaikutuksia. Tuotepohjaisten ja ravintoainepohjaisten verojen vertailu on siten edelleen tutkimaton alue, ja tulevissa tutkimuksissa voitaisiin analysoida useampia tuoteryhmiä (esim. maitotuotteet) ja/tai ravintoaineita (esim. tyydyttynyt rasva, kuidut).
- Nykyajan kuluttajilla on edessään valtava elintarvikevalikoima ja jopa kapeissa tuoteryhmissä elintarvikkeiden ravintosisällöt vaihtelevat suuresti. Tuoteryhmän sisäisiä korvaussuhteita heijastavat laatukysymykset on otettava paremmin huomioon, kun arvioidaan verojen ja tukien vaikutuksia.
- Muista maista saadut kokemukset antavat viitteitä siitä, että verotuskeskustelua ei voida lopulta ratkaista pelkästään ekonometrisiin tutkimuksiin tukeutumalla. Tosielämän kokeet ja

satunnaistetut kontrolloidut tutkimukset tarjoavat vaihtoehtoisen ja mahdollisesti hedelmällisen tutkimusalueen, mutta nämä ovat kuitenkin kalliita ja vaikeasti järjestettäviä tutkimusmuotoja. Lähitulevaisuudessa keskeiseksi tavoitteeksi tulisi asettaa Suomen nykyisen makeisveron vaikutusten arviointi. Myös Tanskassa lokakuussa 2011 käyttöönotetun tyydyttyneen rasvan veron ympärillä käytävää keskustelua on syytä seurata tarkasti.

- Ehdotettujen verokäytäntöjen tähän asti lähes huomiotta jääneet vaikutukset elintarviketeollisuuteen vaativat tutkimista. Tämän on tarpeen, jotta voimme ymmärtää veroratkaisujen vaikutukset kansanterveyteen, sillä elintarviketeollisuuden kaltaisella keskittyneellä toimialalla mikä tahansa vero tai tuki siirtyy hyvin harvoin sellaisenaan lopputuotteisiin. Lisäksi lainsäädännöstä toimialalle koituvat kustannukset on otettava huomioon, kun pyritään arvioimaan sitä, onko ehdotettu veropolitiikka sosiaalisesti perusteltuna – toisin sanoen ovatko politiikan hyödyt suurempia kuin sen kustannukset.

Avainsanat:
rasvavero, sokerivero, ravintoainevero, valmistevero, kansanterveys, liikalihavuus, elintarvikkeiden kysyntä, kysyntäjoustot, ravinteiden joustot

The effectiveness of differentiated food taxes in promoting dietary quality and nutritional health: A review of the international and Finnish evidence

Irz, Xavier and Niemi, Jyrki
MTT Agrifood Research, Economic Research Unit, Latokartanonkaari 9, FI-00790 Helsinki,
firstname.lastname@mtt.fi

Executive summary

In many high-income countries, the rise in obesity and incidence of chronic diseases has lead to calls for the imposition of targeted food taxes and subsidies in order to improve the quality of diets, lower energy intakes, and reduce the burden of diet-related diseases. Finland has followed the trend with the introduction on 1st January 2011 of a small excise tax on confectionaries, ice-cream, and soft drinks, but the debate about the desirability of fiscal instruments to promote public health is ongoing. Important but unresolved questions surround the form of the tax (food-based or nutrient-based? Excise or ad-valorem?), its coverage in terms of product groups or nutrients, whether it should be combined with subsidies to promote consumption of healthy foods, the costs that it imposes on the food industry, and its effectiveness in improving diets and nutritional health. We sought to contribute to that debate by reviewing the theoretical basis for differentiated food taxes (DFTs), and the recent but quickly expanding empirical literature on the subject.

At a conceptual level, DFTs can be justified by the large external costs that are caused by unhealthy diets and related diseases, although it is over-consumption of unhealthy foods, as opposed to moderate consumption, that should ideally be taxed – unfortunately a practical impossibility. More convincingly, there is evidence that consumers do not act rationally when choosing foods and diets, and in that context taxes can be used to correct behavioural failures, such as a lack of self-control. It is important to acknowledge, however, that a tax imposes costs on private individuals and the public sector, and therefore should only be considered socially desirable if its benefits outweigh its costs. This is an empirical question, which relies crucially on the effectiveness of DFTs in driving food choices towards healthier options. In Finland, that question has only been addressed in two recent studies that unfortunately reach different conclusions, with only Kotakorpi et al. (2011) supporting the idea that moderate DFTs would induce sizeable improvements in nutritional health. The other study (Irz, 2010) suggests that energy intake and obesity would hardly be affected by a tax targeting foods high in fat and sugar, while the change in diet quality would be ambiguous.

Although unsatisfactory, the lack of certainty regarding the effect of DFTs in Finland is rather typical of the situation in other countries, which points to the inherent limitations of the econometric techniques that have been applied to date to analyse the subject. The main problem lies with the difficulty of estimating own-price and cross-price elasticities accurately at a level of product disaggregation that makes sense from a nutritional – rather than economic – point of view. Neither of the two Finnish studies seems entirely satisfactory at that level, and it is therefore difficult to argue that, in the Finnish context, the introduction of DFTs is truly evidence-based. In spite of the absence of unambiguous conclusions in the literature, a few important messages emerge from the review.

First, the effect of DFTs on food choices, dietary intakes, and health are complex because taxing a particular food has implications for the entire diet due to the complex and largely unknown relationships of substitutability and complementarity that foods entertain with one another. This is a point of practical importance, as some studies have shown that, due to unintended effects, well-meaning taxes would most likely increase the risk of diet-related diseases rather than decrease it. The complexity of the food choices that have been put to light by empirical research stands in sharp contrast with the way DFTs are typically communicated to the public by labeling the targeted foods as 'junk' and relying on the intuitive appeal of the law of demand.

Second, moderate taxes applied to a broad range of foods deemed unhealthy do not typically generate

large behavioural responses and improvements in diet quality. The Finnish study by Kotakorpi et al. (2011) stands as an exception but the fact that their results rely largely on a single parameter, namely the own-price elasticity of demand for 'sweets and sugar', which is extremely high by international standards, should invite caution when drawing the policy implications of that study.

Third, achieving an unambiguous improvement in diet quality and effective targeting of the policy often requires the combination of several taxes and subsidies. The design of an efficient policy therefore requires the careful comparison of different tax and subsidy schemes in terms of their effects on diet quality and health. Once in place, any policy should be regularly monitored and evaluated, with possible changes to tax rates and range of products or nutrients subject to the tax. An additional advantage of combining a subsidy to a tax would be to alleviate the suspicion that DFTs are introduced as a way of raising government revenue rather than improving public health.

Fourth, an efficient incentive scheme should align its instruments as closely as possible to its public health objective. For instance, if the health policy seeks to reduce consumption of particular energy-dense but nutrient-poor foods (i.e., "empty calories" such as sugar-sweetened beverages), an excise tax which is simple and easy to administer is likely to be more efficient than a nutrient tax. On the other hand, if the objective is to reduce intakes of a given nutrient, taxing foods differentially according to their nutrient content, and hence making it possible for consumers to substitute low-content foods for high-content ones within product groups, is likely to be more efficient than a tax applied uniformly to broad food groups. A nutrient tax presents the additional advantage of creating an incentive for product reformulation towards healthier options by food manufacturers. Ultimately, however, policies should be compared in terms of the costs required to achieve the same improvement in health outcomes.

Fifth, it should not be forgotten that fiscal instruments affect supply as well demand of foods. Rather than assuming a 100% pass-through rate from suppliers to consumers, the transmission of a tax along the food chain needs to be investigated empirically as well.

More specifically about the Finnish policy context, several avenues should be explored in order to inform the ongoing debate:

- In the search for a cost-effective and efficient policy, and noting the limited range of policy instruments that have been studied in Finland to date, more work is needed to identify the incentive schemes capable of delivering large improvements in public health at minimum cost. With respect to the ongoing policy debate, we note that none of the existing studies is capable of capturing the defining feature of a nutrient tax (e.g., sugar tax), which is to link the tax rate of each food to its nutrient content. The comparison of food-based and nutrient-based taxes therefore remains unexplored, and future studies should also include additional food groups (e.g., dairy products) and/or nutrients (e.g., saturated fat, fibers) in the analysis.
- Because modern consumers are faced with a wide choice of foods and, even within narrow product groups, the nutritional content of those foods varies greatly, quality issues reflecting within-group substitutions need to be better taken into account when assessing the effects of taxes and subsidies.
- The experience of other countries suggests that, ultimately, the policy debate is unlikely to be resolved by econometric studies alone. Real-life experiments and randomized controlled trials provide an alternative and potentially fruitful area of research, but are costly and difficult to organize. In the near future, the evaluation of the current confectionary tax in Finland should be set as a priority, and the policy discussion surrounding the saturated fat tax introduced in October 2011 in Denmark should be followed closely.
- The impact of the proposed policies on the food industry, which to date has been largely neglected, should be investigated. This is necessary even to understand the public health impact of the policies, given that the transmission of any tax or subsidy in a concentrated sector such as the food industry is unlikely to be perfect. Further, the costs imposed on industry should be taken into account in any impact assessment seeking to establish whether the proposed policy is socially desirable in the sense that its benefits outweigh its costs.

Keywords:
fat tax, sugar tax, nutrient tax, excise tax, public health, obesity, food demand, demand elasticities, nutrient elasticities

Contents

1 Introduction

The idea of applying differential tax rates in order to influence food choices in general and sugar consumption in particular has a long history. Green (2010) reminds us that the Puritans of post-Colombian United States in Massachusetts used "sumptuary laws" in an attempt to regulate "extravagance in food, dress, tobacco", including a tax on sugar which was at the time regarded as a luxury good. However, it is only in recent decades that, motivated by a rise in the burden of obesity and non-communicable diseases in high-income countries, the notion of taxing unhealthy foods has been considered seriously. Initially proposed by public health experts, this type of intervention has progressed to the top of the policy agenda in many countries. Hence, in October 2011 Denmark became the first country in the world to impose a "fat tax", which imposes a surcharge[1] on foods high in saturated fat, including butter, milk, cheese, pizza, meat, oil and processed foods. In September 2011, Hungary introduced a new tax popularly known as the "Hamburger law" that applies to products containing high levels of salt and sugar, such as soft drinks, ice-cream, sweets, pastries, salty snacks, and food flavorings (Holt (2011) & The Independent, 03 October 2011). Norway already has a tax on sugar and chocolate, while the French government will introduce a tax on sugary soft drinks that is intended to raise €120 million in 2012 (Liberation, 09 September 2011). Even the British Prime Minister, whose conservative party has long advocated "nudging" – rather than forcing – people towards healthier food choices, has admitted that a radical step akin to Denmark's fat tax may be needed in his country (Sydney Morning Herald, 17 October 2011). Outside of Europe, the introduction or strengthening of "soda taxes" is hotly debated in several states of the USA (McColl, 2009) as well as the US senate committee (Tiffin & Arnoult, 2011), and discussions about the social desirability of differentiated food taxes (DFTs) are also ongoing in Australia and New-Zealand.

Unsurprisingly given this international context, the idea of applying differentiated tax rates to foods according to their healthiness has recently received attention in Finland as well. On 1st January 2011 a small excise tax was introduced on confectionaries (75 cents/kg), ice-cream (75 cents/kg), and soft drinks (7.5 cents/l) and a new research report (Kotakorpi et al., 2011), which has received broad media coverage, suggests that the tax should be strengthened and extended to new products[2]. Meanwhile, the National Nutrition Council would see the introduction of a tax on saturated and trans fats positively[3]. Against this background, this report seeks to contribute to the debate on differentiated food taxes by clarifying the rationale for this type of intervention, assessing the strength of the international and domestic evidence regarding the effectiveness of DFTs in improving public health and social welfare, and indentifying research gaps. Given the Finnish policy context, particular attention is devoted to the analysis of fiscal instruments aimed at curbing the consumption of sugar and sugar-rich foods. The review focuses on the behavioural responses of consumers to DFTS and associated changes in diet quality as defined by existing dietary guidelines, and we therefore do not seek to assess the robustness of the epidemiological evidence linking nutrient intakes to disease risks.

This report is an output of MTT's MEGATRENDS research project, which falls under MTT's 'well-being through food' research programs. Financial support from Finnsugar Ltd. is gratefully acknowledged.

[1] The tax rate is 16 kroner per kilogram of saturated fat (Independent, 03 October 2011).
[2] Helsingin Sanomat 24.3.2011 "Tutkimus: Sokerituotteiden kulutus laskuun veron nostolla", MTV3 Internet " Tutkimus: Herkkujen kovempi verotus lisäisi suomalaisten terveyttä".
[3] Helsingin Sanomat 15.03.2010, http://www.hs.fi/english/article/National+Nutrition+Council+looks+set+to+endorse+tax+on+fat/1135254420083

2 Theoretical rationale for DFTs

While this review focuses primarily on the empirical literature on DFTs, it is useful as a starting point to consider the rationale for that type of policy. The public health perspective draws on the observation that our current eating culture results in high human and economic costs related to obesity and diet-related diseases, and the view that better health is always desirable regardless of the costs that must be sacrificed (Strnad, 2005). However, even ignoring the question of the robustness of the epidemiological evidence linking diet quality to negative health outcomes, it is important to consider DFTs in a broader context in order to assess their normative, popular, and political appeal.

The economic rationale for taxing particular foods derives from application of the general principles of welfare economics, which need to be summarized briefly. Simply put, if the free choices of individuals result in an inefficient allocation of resources[4], government intervention is potentially warranted, provided that the benefits of intervention outweigh the costs. The main theoretical contribution of economics in justifying government intervention therefore lies in the characterization of market failures, or situations where a difference between private and social costs (or benefits) results in an inefficient allocation of resources[5]. Hence, according to the normative framework of welfare economics, the presence of market failure is a necessary – although not sufficient – condition for government intervention, which can justify the imposition of a tax (or subsidy) to restore equality of private and social costs (or benefits).

In exploring the fundamental rationale for introducing DFTs, a natural step therefore involves the identification of potential failures affecting food markets. There are three broad areas where food markets may fail in relation to diet-related diseases, which we now review in succession.

First, there can be informational problems that prevent consumers from assessing the full health implications of their choices, leading them to over-consume unhealthy foods. Nutritional information presents some public-good characteristics because, once it is created and reaches the public domain, no one can be prevented from using it, and it follows that private markets tend to under-provide such information. Of course, private businesses invest heavily in advertising, but the kind of information that is conveyed rarely helps people make informed choices, and it can even be argued that valuable dietary advice can sometimes be drowned out by industry advertising (Cawley, 2004). However, while imperfect information provides a convincing argument for labeling regulations as well as the public provision of dietary advice and nutrition education, the case for the use of fiscal measures to correct the market failure seems much less straightforward.

The second relevant type of market failure is due to the presence of externalities, or costs associated with the consumption of particular foods that are not borne directly by the individual consuming the food but, instead, imposed on the rest of society. This is seemingly a powerful argument for intervention in a country such as Finland where the health care costs of treating diet-related diseases are funded through the general tax system. Public health advocates are in fact keen to draw a parallel between taxes on unhealthy foods and taxes on tobacco on the basis of the externality argument. It is important, however, to also stress differences between tobacco and food that makes that parallel risky. While smoking is considered hazardous to health and hence creates an externality at any level of cigarette consumption, it is not possible to argue that consumption in small amounts of a nutrient such as sugar is harmful. This is reflected, for instance, in official dietary advice that does not advocate complete abstinence from sugar consumption but rather recommends a maximum daily amount of consumption[6]. Hence, it is only the over-consumption of particular foods, rather than its consumption, that generates an externality and

[4] The key concept of efficiency is defined as a desirable state of the economy in which it is not possible to make somebody strictly better off without making somebody else worse off, implying that the size of the 'economic cake', or value of the goods and services produced, is maximized.

[5] Efficiency does not guarantee equity, and governments may also want to intervene in order to redistribute resources within the economy.

[6] For instance, the American Heart Association defines a prudent upper limit on sugar intake worth 100 calories per day for men and 150 calories for men (Johnson et al., 2009).

should be taxed according to economic principles, although it is hard to imagine how that theoretical solution could be put into practice. For a healthy non-obese individual with a varied diet, the occasional consumption of a chocolate bar, ice-cream, or can of soda does not create any externality, although a sugar tax is certain to make him/her poorer and reduce his/her welfare. One could also argue that the externality argument applies to many other risk-taking activities, such as the practice of certain sports, and that it is not clear where the line should be drawn between individual responsibility and collective insurance in a system based on the tax-financed provision of health care.

Last, food markets can fail if consumers lack rationality when making food choices, in the sense that they may not act in their own interest, for instance by consuming excessive amounts of unhealthy foods and hence exposing themselves to health problems that lower their overall well-being. It is in fact generally accepted that children are unable to take account of the future consequences of their actions, and that paternalistic interventions such as regulations of advertising to children is therefore desirable. However, the evidence base developed in the fields of behavioural economics supports the view that lack of rationality also applies to adults in most circumstances (Thaler & Sunstein, 2003), including food choices and the decision to partake in physical activity[7]. Research at the frontier of economics and psychology establishes that individuals fail to calculate probabilities correctly, exhibit preference reversals and use heuristics that lead them to make systematic blunders. Even more relevant to the policy debate on diet-related diseases given the long lag between food choices and negative health outcomes is the finding that many people are dynamically inconsistent and have self-control problems (Dodd, 2008). Hence, people overeat in spite of substantial evidence that they want to lose weight, dieters' weight tends to yo-yo, surveys consistently reveal a discrepancy between actual and desired weight, and, more generally, it is difficult to explain the existence of a large diet industry without referring to self-control issues (Cutler et al., 2003).

Altogether, self-control problems and lack of rationality provide the most convincing argument in favour of taxation of unhealthy foods, although it should also be acknowledged that a tax to counteract a tendency to over-consume would penalize individuals who are acting rationally. It is also worth emphasizing that establishing the presence of a market failure, although useful, is not enough to justify government intervention because public policies can also be deficient and result in so-called 'government failure'. To take the example of a sweet tax, the direct effect is that consumers lose welfare because they pay higher prices and consume less of the taxed goods while producers of sweets are also made worse off due to a loss of revenue. These losses are balanced by a gain in tax revenue and, possibly, a gain in public health (the objective of intervention), and to show that the policy is worthwhile in the sense that it increases social welfare, it is necessary to establish that its benefits outweigh its costs (Mazzocchi, Traill and Shogren, 2009, p. 136). Hence, the social desirability of a tax applied to unhealthy food and/or a subsidy to the consumption of healthy foods is ultimately an empirical question, and we now turn to a review of the empirical research on the subject.

[7] In an American context, Paul Krugman puts it more bluntly: 'And even if children weren't a big part of the problem, only a blind ideologue or an economist could argue with a straight face that Americans were rationally deciding to become obese.' (New York Times, 08 July 2005).

3 Review of the international evidence

3.1 Research on the subject

There are few studies of the consumption and public health impacts of an excise tax applied to sugary products as implemented in Finland, and the scope of the review is therefore extended to all nutrient or food-based fiscal measures with the aim of improving nutritional health.

The largest volume of research on the subject comes from the USA and, although European studies are most relevant given the importance of cultural factors in influencing dietary choices, we briefly summarize the main results for that country. That task is facilitated by the work of Powell and Chaloupka (2009) who reviewed in a rigorous and systematic manner the empirical evidence linking food prices to weight outcomes in the USA. They concluded on the basis of only limited evidence that small taxes or subsidies would not be likely to produce significant changes in body mass index (BMI) or obesity prevalence. However, they also suggested that nontrivial price changes may have some measurable effects on Americans' BMI, particularly for children and adolescents, low socio-economic groups, and those most at risk of overweight. Interestingly given the relatively large number of studies published in a US context[8], they considered that strong policy conclusions regarding the effectiveness of fiscal measures aimed at reducing obesity could not be drawn and that additional research was therefore needed.

Following that recommendation, more evidence has been produced in the U.S. in the last few years but the policy message is not becoming clearer. For instance, Andreyeva et al. (2011) have recently estimated that a penny-per-ounce sugar-sweetened beverage (SSB) tax would reduce consumption of those beverages by 24% and energy intake per person per day by 45 kcal, leading to a significant decrease in obesity, while raising $79 billion over 2010-2015. The authors therefore concluded that the proposed tax would significantly improve public health. However, Edwards (2011), in the same journal, raises doubts about the validity of those conclusions, mainly because Andreyeva et al. (2011) do not allow for the possibility of substitutions away from SBBs towards close substitutes (e.g., fruit and vegetable juices, milk, and maybe even alcoholic drinks). Further, Edwards (2011) illustrates the lack of robustness of the evidence base by comparing the results of seven US studies estimating the effect on BMI of a 20% tax on SSBs. The estimated effects, reproduced in Table 1, range from 0.00% for Fletcher et al. (2010 a & b) to -3.29% for Andreyeva et al. (2011), with the latter study standing out by an unusually large simulated effect.

In a European context, Jensen and Smed (2007) compared the cost efficiency of different types of fiscal measures in improving diet quality of the Danish population with an econometrically estimated simulation model. Their empirical results support the proposition derived from the economics of regulation that the cost-effectiveness of a policy instrument depends on the instrument's precision in targeting the economic problem that it is supposed to address. Hence, if the public health objective is formulated in terms of nutrients (e.g., reduction in share of energy derived from saturated fat), a tax or subsidy on nutrients is more efficient (by 10-30 percent) than a tax or subsidy applied to broad food groups. That conclusion is reached, however, without consideration of the administrative problems and costs associated with each type of fiscal measure. The study is also limited in that it does not assess health outcomes, most notably the effect of the tax on obesity and diet-related diseases, which should ideally form the basis of the cost-effectiveness analysis. Of particular relevance to Finnish policy discussions, however, the authors find that a sugar tax at the rate of 5.60DKK per kilogram of sugar would perform poorly as compared to most of the other six fiscal instruments studied. Although sugar intake would decrease by 15.8% as a result of the tax, the simulations suggest that the policy would also induce an increase in the consumption of milk, butter and cheese and associated intakes of fat and saturated fats (by 1.2% and 1.4% respectively). In another dietary dimension, the sugar tax would raise intake of fibers and consumption of fruits and vegetables, but in that respect it would have the smallest effect of all the seven policy instruments considered in the analysis.

[8] The review is based on nine peer-reviewed articles.

In a related Danish study, Smed et al. (2007) confirmed the previous results but also found that taxing a particular nutrient would typically result in undesirable changes in intakes of other nutrients. It follows that several policy instruments would have to be carefully combined in order to achieve unambiguous improvements in diet quality. For instance, achieving a simultaneous reduction in saturated fat and sugar intakes and increase in fiber intake would require the imposition of taxes on the first two nutrients and subsidies on the third one. Further, even that complex policy would not manage to unambiguously improve diet quality for all the socio-demographic groups considered in the analysis, as the simulations suggest that consumers belonging to the highest social class would raise their intake of saturated fat by 52% as a result of the policy. Although the study found that taxes and subsidies induced larger responses from lower socio-demographic groups and therefore generated progressive health effects, it also showed that fiscal measures often missed their main target – for instance, the largest reductions in sugar intakes were simulated for the middle-aged while the principal target group for sugar reduction are the youngest, who have the largest initial consumption level.

On the basis of a large dataset on food purchases of a panel of French consumers, Allais et al. (2010) simulated the impact on nutrient intakes of a 10% tax on energy-rich products, including cheese, butter, cream, sugar-fat products, and ready meals. The tax was estimated to reduce energy intake by 3% and body weight by 2.7kg after nine years for an average male, which is in line with the results of another French study by Etilé (2008), but the impact on diet quality would be ambiguous. For instance, the tax would reduce intakes of all nutritionally relevant minerals, vitamins (with the exception of vitamin E), fibers, and plant proteins. Due to the fact that consumers would not modify their food choices much, the tax would be very effective in raising revenue. However, it would also be extremely regressive since the regulatory burden would be four times larger for low-income households than for well-off households.

Tiffin and Arnoult (2011) simulated the impact of a tax on the saturated fat content of dairy, meat, potato products, cereal products, confectionaries and ready meals coupled with a 15% subsidy on fruit and vegetables consumption in the UK. The health effects were summarized by calculating how the population risk of various diseases would decrease as a result of the policy. The authors concluded that although some adjustments in consumption would be substantial (e.g., for fruits and vegetables) and diet quality would improve, the associated reductions in disease risk would be negligible. This apparent paradox is explained by the fact that the large proportion of the population which is far from recommended levels in intakes, and therefore accounts for the bulk of the population's risk of diseases, would not experience large enough improvements in diet quality following the imposition of the tax. Interestingly, they found that the policy would also lead to an increase in sugar consumption, albeit marginal, which points to the danger of a piecemeal approach considering each nutrient in isolation.

In a similar vein and also in relation to the UK, Nnoaham et al. (2009) analyzed the impact of targeted food taxes and subsidies on consumption, nutrient intakes and related mortality from cardio-vascular diseases and cancer. The study makes clear that even well-meaning taxes can worsen diets as the result of complex substitutions in consumption. For instance, raising the VAT rate by 17.5% on the main sources of saturated fat would likely contribute to between 1100 and 2300 additional deaths every year in the UK. This surprising effect is due to the fact that, although consumption of fat would decrease, fruit and vegetable intake would also fall due to cross-price effects. Those unintended effects could, however, be offset by combining the tax with a subsidy on fruit and vegetable consumption in a revenue-neutral scheme that could prevent up to 6400 deaths annually. The main message from this study is that, while targeted food taxes and subsidies have the potential to improve nutritional health, they should be designed carefully in order to account for the substitutions that inevitably take place in consumption.

This conclusion reinforces that of a previous UK study by Mytton et al. (2007) which also found that raising the VAT rate by 17.5% on the main source of saturated fat was more likely to cause than prevent deaths, although the reason lay in this case with a simulated fall in polyunsaturated fat intake that would raise serum cholesterol. Taxing foods on the basis of an index of nutritional quality called SSCg3d would fare better, preventing 2100-2500 deaths annually, and the best tax scheme, derived through a process of trial and error, would save 2600-3200 lives annually. All three taxes would decrease fruit and vegetable consumption by two to four percent, although that effect was not taken into account in the calculations of the health impacts. Another limitation of the study is that cross-price elasticities, which are shown to be crucial in predicting the health effects of the policies, are assumed rather estimated from consumption data. In spite of methodological shortcomings, that study makes clear that there are inevitable trade-offs when seeking to improve dietary quality by taxing broad food groups. For instance, behaviours of UK consumers imply that reductions in saturated fat are accompanied by reductions in unsaturated fats, with

virtually no effect on serum cholesterol. Meanwhile, the authors put to light a trade-off between the proportion of energy derived from saturated fat and salt intake, and show that salt, which is a nutrient often neglected in other studies, is central to the positive health effects of the policy.

A particularly original UK study by Griffith et al. (2010) investigated the consumption effect of a tax on saturated fat content of butter and margarine products, and established two important results. First, the authors demonstrated empirically that the effect of the tax would not only depend on the responses of consumers to price changes, but also on how the price-setting behaviors of the firms producing the targeted products would adjust to the tax. In an oligopolistic situation typical of the food sector, the pass-through rate measuring the extent to which a tax is passed on to retail prices is often significantly different from 100%, depending on the supply firm's portfolio of products, the level of competition in the industry, and the form of the tax. This mechanism has practical relevance since it explains why an excise tax would be more efficient at reducing saturated fat intake than an ad valorem tax[9]. The second result concerns the importance of including substitutions within broad food categories when assessing the nutritional effects of a tax. By relying on brand-level data, the authors highlighted that even in an apparently narrow group of products such as 'butter' or 'margarines', there remained a lot of heterogeneity in terms of nutritional composition[10], and that those highly-differentiated products were close substitutes, which is reflected in large own-price elasticities[11]. This means that there is a large potential for affecting nutritional intakes by exploiting within-group reallocations (i.e., from products relatively high in saturated fat to substitutes with relatively low saturated fat content).

Gustavsen & Rickertsen (2011) have recently analysed the effect that raising the VAT rate applied to sugar-sweetened carbonated soft drinks (SSCSD) from 13% to 25% would have in Norway. By the use of quantile regressions they were able to differentiate the responses of consumers according to their level of consumption of SSCSD and, maybe surprisingly, found that light and moderate drinkers were more responsive to price changes than heavy drinkers (i.e., they had larger price elasticities in absolute values). This implies that the policy would not be well targeted since those most in need of behavioural change (the heavy drinkers) would also make the smallest relative adjustments to their purchases as a result of the policy. Although in absolute terms heavy drinkers were estimated to reduce SSCSD consumption by the largest amount, that reduction was not statistically significant, leading the authors to conclude that the health benefits for that group would be questionable. The results may be more encouraging from a public health perspective for the group of low to moderate drinkers, which were estimated to reduce their annual consumption of SSCSD by 5.1 to 11.5 liters – a decrease of approximately 5 to 12 kcal per day[12], which would translate into a decrease in body mass of 0.25 to 0.56 kg for men, and 0.42 to 0.94 kg for men. These estimates should, however, be interpreted as upper bounds since the methodology did not allow for the possibility that other beverages, such as milk, may be substituted for SSCSD.

Finally, it is worth pointing out that several reviews of the use of fiscal measures to promote healthy eating have already been published. The WHO (2006) produced an early review focused on saturated fat and energy-dense foods that concluded that there was "no scientific evidence of a causal relationship between policy-related economic instruments and food consumption, including foods high in saturated fats", although "indirect evidence suggest[ed] that such a causal relationship [was] plausible". However, since the publication of that study, much work has been carried out, making a re-evaluation of the evidence base necessary and giving relevance to two more recent European reviews.

First, the French government commissioned last year a multidisciplinary assessment of the state of scientific knowledge on food choices (i.e., what drives them? How can they be influenced?) that included a whole section on fiscal measures (Etiévant et al., 2010). The assessment concluded that the empirical research carried out so far was insufficiently clear to recommend the imposition of taxes on particular foods or nutrients, at least if the objective of the policy was to effect rapid behavioural change and improve the nutritional health of the population[13]. The conclusion was reached on the basis of the lack of robustness and physiological basis of the econometric methods used to simulate that type of policy, the

[9] In both cases, the tax rate is function of the saturated fat content of the product.
[10] The saturated fat content of butter varies from 23.7 g to 57g per 100g and for margarine from 0g to 26.6g.
[11] All the elasticities reported are larger than one and most are larger than two (in absolute value).
[12] We believe that the authors' calculation of the corresponding decrease in body weight is incorrect as it does not take into account how basal metabolic rate adjusts to weight changes. Hence, the changes in BMI that we report use the coefficients reported in Kotakorpi et al. (2011) to convert changes in energy intake into changes in weight.
[13] See Estévian et al. (2010), page 188, second paragraph.

uncertainty that surrounds its long term effects, and the regressive nature of the proposed taxes. The authors suggested that, given the current state of knowledge, perhaps the least problematic form of the policy would involve very small taxes on snacks and soft drinks that would have limited financial effects on consumers but could raise revenue to finance programs of preventions of diet-related diseases.

Finally, as an output of the ambitious EatWell[14] project funded by the European Commission, Capacci et al. (forthcoming, 2012) published a structured review of the effectiveness of various policy instruments, including taxes and subsidies, to promote healthy eating in Europe. They characterized the scientific evidence supporting a positive impact on diet quality as "mixed" for taxes, stressing the uncertainty that surrounds their distributional effects, and "suggestive" in the case of subsidies[15]. Notwithstanding the thinness of the evidence base, the authors suggest that subsidies to healthy foods are likely to be more effective (and cost-effective) than taxes. They reach the overall conclusion that the effects of fiscal measures such as fat taxes and thin subsidies are largely unknown in Europe, while outside of Europe those measures have been shown to effect small behavioural responses (i.e., dietary change). However, while their assessment is hardly an endorsement of financial incentives to promote healthy eating, they do not want to rule out that policy option and point out that, on the basis of simulation studies, large tax rates might generate more substantial effects than those that have been demonstrated in the research literature to date.

3.2 What to make of the international evidence?

The first general conclusion from this review is that the evidence base underlying DFTs is far from robust, even if a relatively large number of studies on the subject have been published in recent years. Comparison of results is hindered by the variety of approaches employed, the types of policies investigated (e.g., tax or subsidies on foods or nutrients), and the outcome variable selected (consumption levels, nutrient intakes, BMI)[16]. However, as evidenced by the literature on SSB taxes in the US, even when a given policy (e.g., 20% tax) is selected for a particular country and outcome variable (i.e., BMI), estimates of effectiveness vary widely. This shows the inherent limitations of the econometric techniques that have been used to date to analyze the issue, and the need to exercise caution when interpreting the results of any particular study.

With those caveats in mind, a few general themes emerge from the international literature on DFTS:

- Moderate taxes and subsidies (under 20%) would generate only limited behavioural responses (changes in consumption) and would therefore only have a small impact on the nutritional health status of the population.

- Because of substitutions in consumption, fiscal instruments can have undesirable effects and increase the risk of diet-related diseases at population level. Hence, if the aim is to improve public health, the policy needs to be carefully designed, and it is likely that unambiguous improvements in dietary quality require a combination of taxes and subsidies.

- The cost-effectiveness of policies should ideally be calculated on the basis of their final health outcomes (e.g., incidence of diet-related diseases) rather than intermediate outcomes (e.g., food/nutrient intakes or diet quality). To the best of our knowledge, however, the literature does not provide a comparison of nutrient-based and food-based taxes on that basis.

- Provided that a clear intermediate public health goal can be defined (e.g., reduction in consumption of energy-dense and nutrient poor foods, reduction in intake of a particular nutrient), an efficient incentive scheme should align its instruments as closely as possible to its public health objective. For instance, if the objective is to reduce intake of a particular nutrient, a nutrient tax is likely to be more efficient than a food-based tax. On the other hand, if the health policy seeks to reduce consumption of particular foods (e.g., "empty calories"

[14] More information on the project's website: http://eatwellproject.eu/en/Home/Welcome/
[15] See Capacci et al. (forthcoming, 2012), Table 8.
[16] Given that the introduction of DFTs is motivated primarily by the rise in obesity, it is surprising that many studies do not even report the effect of the assessed policy on energy intake or BMI.

such as sugar-sweetened beverages), an excise tax which is simple and easy to administer is likely to be more efficient than a nutrient tax.

- Policies targeting particular nutrients rather than broad food groups tend to be more efficient in improving diet quality. However, that conclusion ignores the administrative complexity and costs associated with a nutrient tax/subsidy. Perhaps a compromise between the two options would be a tax/subsidy calculated on the basis of the nutrient profile of each food product.

- Taxes are highly economically regressive, and, maybe more surprisingly, subsidies may also be regressive – for instance, fruit and vegetable subsidies tend to benefit the higher income groups that typically consume more portions of those products.

- The health effects of DFTs are likely to be progressive because low-income groups tend to be more responsive to price changes than better-off groups. However, a more careful look at the issue also suggests that the policies often miss their main target (e.g., limited impact of a soda tax on heavy drinkers in Norway).

- The food sector being imperfectly competitive, a pass-through rate of 100% from tax to retail prices cannot be assumed, and the strategic behavior of firms in the food chain is also important in assessing the effect of any given tax.

- Although the issue has not been investigated thoroughly, the studies that have been carried at a high-level of product disaggregation suggest that tax-driven within-group substitutions can modify nutrient intakes substantially.

Specifically about the Finnish policy debate on sugar taxes, two additional points appear relevant.

- Although the consumption of soft drinks has been investigated thoroughly, we are not aware of any results in the literature available on the type of tax currently in place in Finland (i.e., excise tax applied to a broad range of sugar-rich drinks and food products). However, the UK studies of that type of policy instruments, albeit applied to foods high in saturated fat, are not reassuring as they suggest that their health effects can be rather unpredictable.

- The Danish studies that have investigated the imposition of a tax on sugar content also suggest that it could lead to unintended consequences (e.g., increase in saturated fat intake) and is rather ineffective when compared to other tax and subsidy schemes.

4 Review of the Finnish evidence

4.1 Empirical analyses in Finland

The first empirical analysis of differentiated food taxes in Finland was published by one of the authors of this report last year (Irz, 2010), and the results of three simulations of interest are reported in columns four to six of Table 2. A ten percent "fat tax" imposed on foods high in fat and sugar[17] would result in a qualitative improvement in the Finnish diet, but the magnitude of the change would be extremely small: total energy, fat, and sugar intakes would shrink by only 0.14%, 0.51%, and 1.07% respectively. Meanwhile, due to the adjustments operated by consumers as a result of the tax, fruit and vegetable consumption would be impacted in a way that is not desirable from a nutritional point of view (decrease of -0.48%).

Column five of Table 2 then reports the simulated effect of a "thin subsidy" that would reduce the price of all fruits and vegetables by ten percent. The estimated model suggests that the policy would reach its objective qualitatively (rise in fruit and vegetable consumption), although the behavioural response would be quantitatively limited (0.23% increase) and some changes (e.g., 1.44% increase in sugar consumption) would push the diet further away from the Finnish nutritional recommendations.

The last column of Table 2 reports the simulated effect of a revenue-neutral combination of the two policy instruments[18]. Although the combined tax and subsidy is estimated to reduce fat consumption by 1.26%, it would not result in a nutritionally significant change in calorific intake and would therefore not reduce obesity. Meanwhile, the analysis finds that sugar intake would increase by 1.60% while consumption of fruit and vegetables would actually decrease marginally by 0.06%. This last set of results, while counter intuitive, is however entirely possible given the complex substitutions that take place when only a subset of all foods are taxed or subsidized.

Although this first study has some inevitable shortcomings to which we will return, the picture that it draws is that taxes and subsidies applied to broad food groups in Finland are unlikely to bring about large changes in diet quality or energy intake, and that those instruments are rather blunt in the sense that improvement in diet quality in one dimension is often accompanied in a worsening of the diet in another dimension. Further, the substitutions operating across foods result in a near constant energy intake, implying that fiscal measures are unlikely to have a major effect on the incidence of obesity in the Finnish population.

The second study (Kotakorpi et al., 2011)[19] examines the consumption and public health effect of different combinations of differentiated food taxes and subsidies, pushing the analysis one step further by considering the impact of dietary changes on the incidence of obesity, cardio-vascular diseases, and type-2 diabetes. That aspect of the modeling exercise aside, the approach shares many similarities with that of Irz (2010): a complete system of demand grounded in microeconomics supports the estimation of relevant price elasticities, which are then used to derive changes in food consumption and nutrient intakes resulting from each policy. However, the conclusions that are reached are fundamentally different, as the authors find broad support for the idea that financial instruments applied differentially to foods would be effective in reducing obesity and the incidence of diet-related diseases in Finland.

More precisely, a sugar tax of one Euro per kilogram that would increase the price of the 'sugar and sweets' group by 9.2% and that of the 'bread' group by 1.7% is estimated to reduce the average body weight of the Finnish population by 1.4 kg, hence shifting the BMI distribution significantly to the left.

[17] Defined on the basis of the classification of consumption used in the National Accounts. The tax covers the product groups: cakes & pastries, fats and oils (butter, margarine, oils, cream), sugar products (sugar, honey, jam), confectionaries and chocolate, as well as ice-cream.

[18] More precisely, a 10% fat tax and a 18.5% thin subsidy.

[19] This assessment was made on the basis of the preliminary English version of the study gratefully provided by J. Pirttilä on 24 March 2011. The tables summarizing the simulation results appear to be identical in the published document in Finnish and its unpublished English version.

The percentage of obese (BMI> 30) and overweight (25<BMI<=30) individuals would consequently decrease by 2.2% and 2.4% respectively. The epidemiological model then translates those changes into a 6% reduction in the prevalence of diabetes and a 1.4% reduction in the incidence of cardio-vascular diseases. The savings in health costs related to the reduction in the number of Finns afflicted by diabetes alone would amount to €50 million annually.

Kotakorpi et al. (2011) also simulate the impact of a 'thin subsidy' abolishing the value-added tax (VAT) on fruits, vegetables, and fish, which is currently set at 13% for all foods. Although the policy would increase consumption of the selected food groups and consequently improve diet quality, it would also result in a rise in overall energy intake and obesity. The net effect would be a marginal decrease in the incidence of cardio-vascular mortality (-0.4%) and a rise in the incidence of diabetes (not quantified).

If the tax and subsidy were combined, the reduction in average body weight (-0.37 kg) and diabetes incidence (-1.2%) would be limited. However, the authors also suggest that the policy would cause an increase in intake of healthy nutrients from fruits, vegetables and fish, which would in turn reduce mortality attributable to coronary heart diseases.

4.2 What to make of the Finnish evidence?

Comparison of the two Finnish studies is complicated by the fact that their results are presented in different formats. However, a rough analysis suggests that the discrepancies are fundamental rather than presentational, as suggested by the sharply different conclusions reached by the authors. For instance, the 0.14% decrease in energy intake resulting from the 10% fat tax in Irz (2010) applied to a daily intake of 2100 kcal gives a reduction of 3 kcal/day, which can be estimated to reduce average body weight by less than 200g[20]. This is in sharp contrast with the 1.4 kg reduction found in Kotakorpi et al. (2011) for a lower tax rate, and although this rough calculation is only meant to be illustrative, it is impossible to escape the conclusion that the two sets of results are inconsistent, at least as far as the impact of a tax is concerned.

Before attempting to seek an explanation for this discrepancy, it is also important to highlight the elements of commonality between the two studies. For instance, in both cases the thin subsidy results in an increase in total energy intake and hence obesity, although the increase in Irz (2010) is extremely small. The conclusion that subsidies, or combinations of taxes and subsidies, are rather blunt instruments to improve diets therefore seems to apply to both studies. However, the current policy debate centers on taxes and we now investigate potential reasons for the differing assessments of effects of that type of policy in an attempt to evaluate the robustness of the evidence and highlight potential research gaps.

Nature of the simulated tax

On the face of it, the two studies simulate two different policy instruments: Irz (2010) considers an ad valorem tax on foods high in fat and sugar, while Kotakorpi et al. (2011) focus on a tax on sugar content at the rate of €1/kg. However, the difference is only superficial because the degree of product aggregation in the latter study is such that an average tax rate is in fact applied to all foods in the targeted product groups (namely, 9.2% to the 'sweets & sugar' group and 1.7% to the 'bread' group). [21] Hence, no Finnish study to date has been able to capture the fundamental characteristic of a sugar tax, which is to impose different tax rates on foods with different sugar contents, and the policies examined in the two existing studies are therefore qualitatively similar. We also note that the comparison of the simulated 'sugar tax' with the existing excise tax in Kotakorpi et al. (2011, p. 31-32) only states that a tax at a rate of 9.2% would have a larger effect than a tax at the rate of 5.3%, which says nothing about the relative cost-effectiveness of the two types of taxes.

[20] The value of 2100 kcal is based on the energy requirements published in Table 1 of the Finnish Nutrition Recommendations (National Nutrition Council, 1998). We then use the epidemiologic evidence presented in Kotakorpi et al. (2011) according to which a daily reduction of 20 kcal for men and 12 kcal for women is associated with a one kilogram reduction in body weight. We therefore used the average value (16 kcal) to convert the decrease in energy intake into weight loss for the entire population.

[21] The assumption that a 1.7% tax imposed on the group covering bread and sweet pastry would have the same effect, in terms of energy and nutrient intakes, as a 9.2% tax imposed exclusively on sweet pastries (and 0% imposed on bread) represents an approximation.

At another level, the product coverage of the taxes in the two studies differs somewhat, with Irz (2010) including fats and oils in the target group of products, while Kotakorpi et al. (2011) include soft drinks and bread. However, those differences, while important, do not seem sufficient to explain a ratio of one to seven in the level of the outcome variable (namely reduction in body weight).

Magnitude of demand elasticities

The two studies follow a similar approach in attempting to measure the responsiveness of consumers to the imposition of a tax by estimating the price elasticities of demand for the taxed goods. The elasticities used in the simulations are reported in Tables 3 and 4. The key parameter to estimate the effect of the sugar tax in Kotakorpi et al. (2011) is the own price elasticity of demand for sweets and sugar products, the estimate of which is -2.543 (Table 3). Although the elasticity is estimated imprecisely, as shown by the large standard error, it is statistically significant and negative, hence conforming to the law of demand. However, its magnitude is extremely large in absolute value since it implies that a 10% increase in the price of sweets and sugar would induce a 25% decrease in demand for those foods.

This is a surprising finding as economists typically consider that demand for foods is inelastic, meaning that we would expect an elasticity smaller than unity in absolute value. This is in fact what Irz (2010) found for 24 of 25 food groups, the one exception corresponding to the 'other meat products' category with an own-price elasticity of -1.57 (Table 4). Although the grouping of products impedes comparison of the two studies, the own price elasticity of -2.543 in Kotakorpi et al. (2011) for all sweet and sugar products should be related to similar elasticities worth -0.54 for cakes and pastries, -0.38 for the sugar product group (sugar, honey, jam etc.), and -0.61 for confectionaries in Irz (2010).

Further, the above elasticities can easily be compared to those reported in the academic literature for the United States, which is clearly the country where the most research on the issue of food demand has been carried out. Andreyeva et al. (2010) recently reviewed 160 relevant studies and their results are summarized in Table 5. For all 16 food groups, the mean price elasticity is smaller than one in absolute value, and the corresponding 95% confidence interval has an upper bound smaller than one in absolute value for 14 of the 16 food groups, giving strong empirical support to the idea that, as a rule, demand for food is inelatistic. Turning to the food groups of interest, the mean elasticity for sweets/sugar is -0.34, with a 95% confidence interval spanning -0.14 to -0.53 and the largest elasticity (in absolute value) out of 13 estimates equal to -1. For soft drinks (14 estimates), the mean elasticity is -0.79 with a 95% confidence interval of -0.33 to -1.24, and a maximum elasticity of -3.18. In a European context, Smed et al. (2007) report own-price elasticities of demand for sugar products for different socio-economic groups that indicate that the population average would be slightly larger than -1 (i.e., smaller than one in absolute value).

In light of this evidence, and the general result that the absolute value of the own-price elasticity of demand tends to decrease as the degree of product aggregation increases, the elasticity used in Kotakorpi et al. (2011) seems extraordinarily large.

Expenditure versus physical quantity

The two empirical Finnish studies rely on data of a very different nature. Irz (2010) uses annual aggregate consumption expenditure data from the Finnish national accounts combined with data on physical quantities of food commodities consumed in Finland from 1975 to 2006, as estimated in Tikes's food balance sheets. Kotakorpi et al. (2011) use detailed household level data on food consumption expenditure from the 1995, 1998, 2001 and 2006 rounds of the Finnish Household Budget Survey (HBS), which are combined with monthly price indices recorded by Tilastokeskus. The second dataset is *a priori* much superior to carry out the simulations of the tax: its size (17,000 versus 32 observations) is attractive from a statistical point of view, the household level of analysis allows for the analysis of the distributional effects of the tax on different socio-economic groups, and the fact that the data does not span too far in the past makes the implicit assumption of absence of structural change in consumer tastes relatively more plausible. However, it also has a fundamental shortcoming in that it only records consumption expenditure (i.e., the amount spent on different types of food) rather than the physical quantities that are

consumed[22]. Hence, we now turn to the question of whether it is reasonable to estimate changes in diets exclusively on the basis of data on food expenditure.

The problem can first be studied theoretically by relying on the large economic literature that investigates the 'quality versus quantity' issue in consumption, which started with the seminal contributions of Houthakker (1952) and Theil (1952). As demonstrated by Nelson (1991), for any food group G, expenditure-based quantity indices[23], denoted by Q_G, relate not only to the physical quantity of the goods in the group, denoted by q_G, but also the quality of the goods consumed, denote by v_G: $Q_G=v_G q_G$. Quality here refers to the unit value of the foods in group G, calculated using reference prices, as expenditure divided by physical quantity (i.e., average price per kilogram). Hence, for a given consumer or household, changes in quality of food group G are associated with reallocations of purchases to lower or higher price goods within that group. For instance, a switch from a high-priced bottle of Innocent smoothie to a bottle of Coca-Cola of similar size would lead to a decrease in quality of the 'sweets and sugar' group, that includes all non-alcoholic drinks. Although the physical quantity would remain constant since it was assumed that the bottles were of equal size, the theoretical relationship implies that the expenditure-based quantity index Q_G would also decrease. Hence, physical quantity and expenditure-based quantity indices can fluctuate very differently if consumers respond to changes in their environment by adjusting the quality of the goods that they purchase.

Why is this abstract theoretical point relevant to the discussion on fat and sugar taxes? Following the introduction of a tax on 'sweets and sugar', consumers would face higher prices on those goods and may decide to downgrade in quality, hence replacing Tropicana juice with juice from concentrate, or Fazer chocolate with cheaper candies. Those adjustments may have a large impact on expenditure-based quantity indices, because the decrease in the price of the consumed items would result in lower overall quality of the 'sweets and sugar' group, but very little effect on the nutritionally-relevant physical quantities of the foods (and related nutrients) consumed. Basing the simulations of the health effects of the tax on elasticities derived from expenditure-based quantities therefore seems problematic.

Kotakorpi et al. (2011) only implicitly rely on expenditure-based quantity indices to estimate demand elasticities, since their empirical model is a system of budget share equations. However, the problem highlighted above remains, as is made clear from the following quote: "…elasticities estimated using a regression of budget share on price still implicitly assume that price changes have no impact on quality" (McKelvey, 2011, p. 161-2). Hence, the changes in demand reported in Kotakorpi et al. (2011) (e.g., 23% decrease in 'sugar and sweets') only measure changes in the physical quantity of the foods consumed if we accept that quality adjustments do not take place.

We would argue that this is not a tenable assumption first based on the results of the empirical literature on the subject, which is unfortunately rather thin as far as high-income countries are concerned. However, some examples suggest that quality adjustments in the estimation of price elasticties can lead to serious biases. For instance, Reed, Levedhal and Clark (2003) estimated the price elasticities of demand[24], quantity, and quality for different meats in the U.S., and found that quality adjustments were very large. For instance, according to the first row of figures in Table 6, a 10% increase in beef price would result in a 14% decrease in demand. This large decrease would, however, be accounted for the most part (13%) by a decrease in quality (e.g., switch from filet beef to ground beef), with only a relatively marginal decrease in the physical quantity of meat consumed (1%). In some cases, the quality adjustments are so large that physical quantity and expenditure-based quantity can respond in different directions to a price change (see impact of pork prices on demand for pork). Although the context and product focus of that study are not directly relevant to the analysis of food taxes in Finland, the results suggest that the issue of quality adjustments cannot be assumed away *a priori* when assessing the health effects of food taxes in Finland.

A second argument relies on examination of the implications of the expenditure elasticities reported by Kotakorpi et al. (2011). If elasticities in Table 3[25] can be interpreted as responses of physical quantities to price changes, Table 4 (of that study) should be interpreted similarly as responses of physical quantities of

[22] To be more precise, the data includes physical quantities for the 2006 round of the HBS, but that data is not used in the estimation of the demand elasticties or in the simulations, except to calculate the average tax rate of the 'bread' group.
[23] By this we mean current-price expenditure deflated by an appropriate price index, or constant-price expenditure.
[24] In terms of the terminology used previously, demand means expenditure-based quantity.
[25] Table 3 of Kotakorpi et al. (2011), reproduced as Table 3 here as well.

food consumed to changes in consumption expenditure. By examination of the Tilastokeskus' statistics on household consumption[26], we calculate that real private consumption expenditure has grown at the annual rate of 2.9% between 1995 and 2006 (the period covered by the data). On the basis of the expenditure elasticities of Kotakorpi et al. (2011), this implies annual growth rates in consumptions of bread, meat, fish, fruits & vegetables, and sugar & sweets worth 1.0%, 1.1%, 2.0%, 1.7%, and 1.0% respectively. If those changes are interpreted as changes in physical quantities, the corresponding change in energy intake is a weighted average of those percentages, with the weights being equal to each food group's share of energy intake, which are positive. Although we do not know the weights, the previous rates of growth imply an annual growth of energy intake of at least 1.0%, with 1.1% representing a conservative estimate. Applying this last percentage to average energy requirements of 1900 kcal for women and 2300 kcal for men, the corresponding annual increase in energy is 21 kcal for women and 25 kcal for men. Using the coefficients reported in Kotakorpi et al. (2011), this translates into **annual** increases in body weight equal to 1.7 kg for women and 1.3 kg for men. The conclusion of this quick calculation is therefore that a single year of average growth in living standards is enough to offset the one-off effect on obesity of the tax simulated by Kotakorpi et al. (2011).

However, the result is hardly plausible, since it also implies that, ceteris paribus, economic growth alone should have resulted in most Finns being severely obese, which we do not observe. We would suggest that the problem lies with the assumption of absence of quality effects. In high-income economies in which consumers only spend a small share of their resources on food, changes in food consumption are in fact dominated by quality effects: consumers respond to changes in their environment (e.g., prices, income) primarily by switching to products with different attributes (e.g., convenience, food safety, taste etc.) rather than by adjusting purchased quantities. This is for instance the result of a recent U.S. study on consumption of green leafy vegetables. On the basis of very detailed scanner data on food purchases, Kuchler (2011) concluded that while quantity purchased was irresponsive to changes in income, there was strong evidence that consumers adjusted to income variations by varying their demand for convenience (e.g., choice of bagged salad vs fresh lettuce).

We now provide some suggestive evidence that quality effects are indeed important in Finland as well. Table 7 reports the results of calculations described in Appendix 1 that decompose growth in food consumption into a quality component and a physical quantity component over the 1995-2006 period for some relevant food groups. According to the data, ice-cream consumption grew by 11.6% over that period, but virtually all that increase was accounted for by quality growth (i.e., switches to higher-priced products). For fish, vegetables and potatoes, quality increases accounted for more than half of the growth in consumption. Physical quantity is only quantitatively more important than quality in accounting for growth in the case of the 'bread and cereals' group, while the calculation for the 'fruit' category appears anomalous as it indicates that quality and quantity changed in opposite directions from 1995 to 2006, with quality actually decreasing[27]. Overall, those simple calculations indicate that food consumption growth in Finland is driven primarily by increases in the quality of the goods consumed rather than their physical quantity. Further, given that the response of consumers to a price change has both an income effect and a substitution effect, it seems likely that the imposition of taxes on particular foods generates important quality adjustments.

Irz (2010) attempted to address this issue by developing a method to relate the physical quantities of the FBS data to the consumption volumes recorded in the National Accounts, which could in part explain the large difference in results between the two Finnish studies. However, it must also be acknowledged that tackling the quality issue at the national aggregate level is extremely difficult due to the limitations of the available data, and in particular the lack of a clear correspondence between the product categories in the

[26] Series A01_12 Total consumption expenditure at 2006 prices, available here: http://pxweb2.stat.fi/database/StatFin/tul/ktutk/ktutk_en.asp

[27] A careful look at the data reveals that the result is driven entirely by an exceptionally low level of fruits available for consumption in 1995 as recorded in the FBS data. When the 1995 base year is replaced by either 1994 or 1996, the calculation produces positive increases in quality of the fruits consumed. However, we have not found any satisfactory explanation for this sharp decline in the FBS data.

national accounts and FBS[28]. In fact, even in the international academic literature, that issue has not been addressed in a satisfactory manner.

Level of aggregation

Another related and important difference between the two studies relates to the level of product aggregation in the analysis. Irz (2010) investigates demand for 25 food product groups, while Kotakorpi et al. (2011) base their results on a highly aggregated model that categorizes all foods into five groups.[29] Based on the literature review, the latter level of aggregation seems very unusual when considering the impact of a tax on the entire diet. Further, it is an important characteristic of the model because the aggregates are then treated as homogeneous foods when they are combined to fixed nutrient conversion coefficients to calculate nutrient intakes. Obviously, the higher the degree of product aggregation, the less tenable is that assumption. Beyond the technical difficulties, grouping together very different products (e.g., ice-cream, soft-drinks) can be problematic when assessing patterns of substitutability and complementarity. For instance, it seems reasonable to assume that soft drinks and milk are substitutes, but the relationship between ice-cream and milk is much less clear,[30] although a highly aggregated model that places both products into a 'sugar and sweets' category is unable to capture that type of differences.

[28] Those limitations are apparent, for instance, in the lack of explanatory power of some of the regressions reported in Table 2 of Irz (2010), as well as some large income elasticities of demand for nutrient in Table 3 of the same paper.

[29] The sixth group includes dairy products, fats, as well as all non-food products.

[30] For instance it could be argued that ice-cream consumption increases thirst, leading to higher consumption of milk, i.e. that the two products are complements rather than substitutes. Similarly, it seems intuitive that fruits and soft drinks are complements, while fruits and ice-cream (two types of dessert or snacks) are substitutes.

5 Discussion and conclusion

Differentiated food taxes have been introduced in Finland with the aim of reducing obesity and the related incidence of diet-related diseases, and there are on-going discussions about the future of the policy: should the tax apply to broad product groups or be a function of nutrient content? Should the tax be extended to include new nutrients or food groups? Should a subsidy to the consumption of healthy foods or nutrients accompany the tax applied to unhealthy foods? And how effective are DFTs in achieving their objective? This paper sought to contribute to that debate by reviewing the theoretical basis for DFTs, and the recent but quickly growing empirical literature on the effectiveness of DFTs in promoting health.

At a conceptual level, DFTs can be justified by the large external costs that are caused by unhealthy diets and related diseases, although it is over-consumption of unhealthy foods, as opposed to moderate consumption, that should ideally be taxed – unfortunately a practical impossibility. More convincingly, there is evidence that consumers do not act rationally when choosing foods and diets, and in that context taxes can be used to correct behavioural failures, such as a lack of self-control. It is important to acknowledge, however, that a tax imposes costs on private individuals and the public sector, and therefore should only be considered socially desirable if its benefits outweigh its costs. This is an empirical question, which relies crucially on the effectiveness of DFTs in driving food choices towards healthier options. In Finland, that question has only been addressed in two recent studies that unfortunately reach different conclusions, with only the more recent study supporting the idea that moderate DFTs would induce sizeable improvements in nutritional health. The other study suggests that energy intake and obesity would hardly be affected by a tax targeting foods high in fat and sugar, while the change in diet quality would be ambiguous.

Although unsatisfactory, the lack of certainty regarding the effect of DFTs in Finland is rather typical of the situation in other countries, which points to the inherent limitations of the econometric techniques that have been applied to date to analyse the subject. The main problem lies with the difficulty of estimating own-price and cross-price elasticities accurately at a level of product disaggregation that makes sense from a nutritional – rather than economic – point of view. Neither of the two Finnish studies seems entirely satisfactory at that level. In spite of the absence of unambiguous conclusions in the literature, a few important messages emerge from the review.

First, the effect of DFTs on food choices, dietary intakes, and health are complex because taxing a particular food has implications for the entire diet due to the complex and largely unknown relationships of substitutability and complementarity that foods entertain with one another. This is a point of practical importance, as some studies have shown that, due to unintended effects, well-intended taxes would most likely increase the risk of diet-related diseases rather than decrease it. The complexity of the food choices that have been put to light by empirical research stands in sharp contrast with the way DFTs are typically communicated to the public by labeling the targeted foods as ‘junk’ and relying on the intuitive appeal of the law of demand.

Second, moderate taxes applied at the same rate to a broad range of foods deemed unhealthy do not typically generate large behavioural responses and improvements in diet quality. The Finnish study by Kotakorpi et al. (2011) stands as an exception but the fact that their results rely largely on a single parameter, namely the own-price elasticity of demand for ‘sweets and sugar’, which is extremely high by international standards, should invite caution when drawing the policy implications of that study.

Third, achieving an unambiguous improvement in diet quality often requires the combination of several taxes and subsidies. The design of an efficient policy therefore requires the careful comparison of different tax and subsidy schemes in terms of their effects on diet quality and health. Once in place, any policy should be regularly monitored and evaluated, with possible changes to tax rates and range of products or nutrients subject to the tax. An additional advantage of combining a subsidy to a tax would be to alleviate the suspicion that DFTs are introduced as a way of raising government revenue rather than improving public health.

Fourth, an efficient incentive scheme should align its instruments as closely as possible to its public health objective. For instance, if the health policy seeks to reduce consumption of particular energy-dense but nutrient-poor foods (i.e., "empty calories" such as sugar-sweetened beverages), an excise tax which is simple and easy to administer is likely to be more efficient than a nutrient tax. On the other hand, if the objective is to reduce intakes of a given nutrient, taxing foods differentially according to their nutrient content, and hence making it possible for consumers to substitute low-content foods for high-content ones within product groups, is likely to be more efficient than a tax applied at the same rate to broad food groups. A nutrient tax presents the additional advantage of creating an incentive for product reformulation towards healthier options by food manufacturers. Ultimately, however, policies should be compared in terms of the costs required to achieve the same improvement in health outcomes.

Fifth, it should not be forgotten that fiscal instruments affect supply as well demand of foods. Rather than assuming a 100% pass-through rate from suppliers to consumers, the transmission of a tax along the food chain needs to be investigated empirically as well.

More specifically about the Finnish policy context, several avenues should be explored in order to inform the ongoing debate:

- In the search for a cost-effective and efficient policy, and noting the limited range of policy instruments that have been studied in Finland to date, more work is needed to identify the incentive schemes capable of delivering large improvements in public health at minimum cost. With respect to the ongoing policy debate, we note that none of the existing studies is capable of capturing the defining feature of a nutrient tax (e.g., sugar tax), which is to link the tax rate of each food to its nutrient content. The comparison of food-based and nutrient-based taxes therefore remains unexplored, and future studies should also include additional food groups (e.g., dairy products) and/or nutrients (e.g., saturated fat, fibers) in the analysis.

- Because modern consumers are faced with a wide choice of foods and, even within narrow product groups, the nutritional content of those foods varies greatly, quality issues reflecting within-group substitutions need to be better taken into account when assessing the effects of taxes and subsidies.

- The experience of other countries suggests that, ultimately, the policy debate is unlikely to be resolved by econometric studies alone. Real-life experiments and randomized controlled trials, as for instance recently used in New-Zealand (Mhurchu et al., 2010)[31], provide an alternative and potentially fruitful area of research. Evaluation of the current confectionary tax in Finland should also be set as a priority, and the policy discussion surrounding the saturated fat tax in Denmark should be followed closely.

- The impact of the proposed policy on the food industry, which to date has been entirely neglected, should be investigated. This is necessary even to understand the public health impact of a policy, given that the transmission of any tax or subsidy in a concentrated sector such as the food industry is unlikely to be perfect. Further, the costs imposed on industry should be taken into account when establishing whether the proposed policy is socially desirable in the sense that its benefits outweigh its costs.

[31] The study found that price discounts had no significant effect on nutrients purchased.

6 References

Allais, O., Bertail, P. & Nichèle, V. (2010). The effects of a fat tax on French households' purchases: a nutritional approach. American Journal of Agricultural Economics 92(1): 228-245.

Andreyeva, T., Long, M. W. & Brownell, K. D. (2010). The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food. American journal of Public Health 100(2): 216-222.

Andreyeva, T., Chaloupka, F. J. & Brownell, K. D. (2011). Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue, Preventive Medicine 52: 413-416.

Capacci, S., Mazzocchi, M., Shankar, B., Macias, J. B., Verbeke, W., Pérez-Cueto, F. j. A., Kozioł-Kozakowska, A., Piórecka, B., Niedzwiedzka, B., D'Addesa D., Saba, A., Turrini, Aschemann-Witzel, J., Bech-Larsen, T., Strand, M., Wills, J. & Traill, W. B. (forthcoming, 2012). Policies to promote healthy eating in Europe: A structured review of instruments and their effectiveness, Nutrition Reviews.

Cawley, J. C. (2004). An economic framework for understanding physical activity and eating behaviors, American journal of Preventive Medicine 27(3S): 117-125.

Cutler, D. M., Glaeser, E.L. & Shapiro, J. M. (2003) Why have Americans become more obese?, The Journal of Economic Perspectives 17(3), 93-118.

Dodd, M. (2008). Obesity and time-inconsistent preferences, Obesity Research & Clinical Practice 2, 83-89.

Edwards, R. D. (2011). Commentary: Soda taxes, obesity, and the shifty behavior of consumers, Preventive Medicine 52: 417-418.

Etiévant, P., Bellisle, F., Dallongeville, J., Etilé, F., Guichard, E., Padilla, M. & Romon-Rousseaux M. (éditeurs) (2010). Les comportements alimentaires. Quels en sont les déterminants ? Quelles actions, pour quels effets ? Expertise scientifique collective, rapport, INRA (France), 275 p.

Etilé, F. (2008). Food price policies and the distribution of body mass index: The French case. Mimeo, Paris School of Economics N2008-28.

Fletcher, J.M., Frisvold, D. & Teft, N. (2010a). Taxing soft drinks and restricting access to vending machines to curb child obesity, Health Affairs 29(5): 1059-1066.

Flecther, J.M., Frisvold, D. & Teft, N. (2010b). The effects of soft drink taxes on child and adolescent consumption and weight outcomes. Journal of Public Economics 94(11-12): 967-974.

Green, R. (2010). The ethics of sin taxes, Public Health Nursing 28(1): 68-77.

Griffith, R., Nesheim, L. & O'Connel, M. (2010). Sin taxes in differentiated product oligopoly: an application to the butter and margarine market, Cemmap working paper CWP37/10, The Institute of Fiscal Studies, London.

Gustavsen, G. W. & Rickertsen, K. (2011). The effects of taxes on purchases of sugar-sweetened carbonated soft drinks: a quantile regression approach, Applied Economics 43: 707-716.

Holt, E. (2011). Hungary to introduce broad range of fat taxes, The Lancet 378(9793): 755.

Houthakker, H. S. (1952). Compensated changes in quantities and qualities consumed, Review of Economic Studies 19: 155-64.

Irz, X. (2010). Modeling physical quantities of food and nutrients consumed from aggregate data - with an application to Finland, Agricultural Economics 41: 293-304.

Jensen, J. D. & Smed, S. (2007). Cost-effective design of economic instruments in nutrition policy, International Journal of Behavioral Nutrition and Physical Activity 4(10).

Johnson, R. K., Appel ,L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H. et al. (2009). Dietary Sugars Intake and Cardiovascular Health, Circulation 120: 1011-1020.

Kotakorpi, K., Härkänen, T., Pietinen, P., Reinivuo, H., Suoniemi, I. & Pirttilä, J. (2011). Terveysperusteisen elintarvikeverotuksen vaikutukset kansalaisten terveydentilaan ja terveyseroihin. Terveyden ja Hyvinvoinnin Laitos (THL), Rapportti 7/2011.

Kuchler, F. (2011). Is it Food Quality or Quantity that Responds to Changing Income? Applied Economic Perspectives and Policy 33(2): 205-221.

Mazzocchi, M., Traill, B., & Shogren, J. F. (2009). Fat Economics, Oxford University Press, Oxford, UK.

McKelvey, C. (2011). Price, unit value, and quantity demanded, Journal of Development Economics 95: 157-169.

McKoll, K. (2009). Fat taxes and the financial crisis, The Lancet, 373: 797-8.

Mhurchu, C. N., Blakely, T., Jiang,Y., Eyles, H. C. & Rodgers, A. (2010). Effects of price discounts and tailored nutrition education on supermarket purchases: a randomized controlled trial, The American Journal of Clinical Nutrition, 91:736-47.

Mytton, O., Gray, A., Rayner, M. & Rutter, H. (2007). Could targeted food taxes improve health? J Epidemiol Community Health 61:689–694.

Nelson, J. (1991). Quality variation and quantity aggregation in consumer demand for food, American Journal of Agricultural Economics, 73(4): 1204-1212.

Nnoaham, K. E., Sacks, G., Rayner, M., Mytton, O. & Gray, A. (2009). Modelling income group differences in the health and economic impacts of targeted food taxes and subsidies, International Journal of Epidemiology 38: 1324-1333.

Powell, L. M. & Chaloupka, F. J. (2009). Food prices and obesity: evidence and policy implications for taxes and subsidies, Milbank Quarterly 87(1): 229-257.

Reed, A. J., Levedahl, J. W., & Clark, J. S. (2003). Commercial disappearance and composite demand for food with an application to U.S. meats, Journal of Agricultural and Resource Economics 28(1): 53-70.

Smed, S., Jensen, J. D. & Denver, S. (2007). Socio-economic characteristics and the effect of taxation as a health policy instrument, Food Policy 32: 624-639.

Strnad, J. (2005). Conceptualizing the "Fat Tax": The Role of Food Taxes in Developed Economies, S. Cal. L. Rev. 78: 1221.

Thaler R.H. & Sunstein C.R. (2003) Libertarian paternalism, The American Economic Review 93(2), 175-179.

Theil, H. (1952). Qualities, prices, and budget inquiries. Review of Economic Studies 19: 129-147.

Tiffin, R. & Arnoult, M. (2011). The public health impacts of a fat tax, European Journal of Clinical Nutrition 65: 427-433.

World Health organization (2006). What is known about the effectiveness of economic instruments to reduce consumption of foods high in saturated fats and other energy-dense foods for preventing and treating obesity? WHO Regional Office for Europe's Health Evidence Network (HEN).

7 Annex

Annex 1: Quality versus quantity in consumption growth

As stated in the main text, expenditure-based quantity or consumption volume Q_G relates to physical quantity q_G and quality v_G through the following equality: $Q_G=q_G\ v_G$. Theil's index of quality v_G can therefore be calculated if we have information on the other two variables. In some cases, this information is available at the national aggregate level. Consumption volumes are reported in the National Accounts as private consumption expenditure at reference year 2000 prices. Physical quantities of foods available for consumption are recorded in Tike's food balance sheets (FBS). A problem arises when attempting to combine the two datasets because the FBS is expressed in terms of agricultural commodities (e.g., wheat) rather than the final good consumed (bread). In some cases, however, it is possible to relate product categories in the two data sets to calculate a quality index ($v_G=Q_G/q_G$). Once the index has been calculated, it is straightforward to decompose growth in consumption γ_{QG} into its quantity (γ_{qG}) and quality (γ_{vG}) components $\gamma_{QG}= \gamma_{qG} +\gamma_{vG}$. The contribution of quality growth to consumption growth is then simply expressed as the ratio γ_{vG}/ γ_{QG}.

In the case of the 'sweets and sugar' group, it is not possible to find an equivalent category in the FBS, which only reports availability of sugar, syrup, honey and molasses, while a lot of sugar is consumed in processed products (e.g., cakes, biscuits, soft drinks, snacks). However, ice-cream appears as such in both datasets and is therefore included in Table 7. In the case of fruits, vegetables and potatoes, own-consumption has been excluded to calculate consumption growth. The fruit category excludes fruit juices in the FBS and the vegetables category does not include potatoes.

Table 1: Estimated marginal effects of a 20% increase in the tax rate of sugar-sweetened beverages (Edwards, 2011).

Study	Design	Universe	Accounts for substitution	Change in BMI (%)
Andreyeva et al. (2011)	Calibration	Population	No	−3.29
Finkelstein et al. (2010)	Cross section	Households	Yes	−0.46
Fletcher et al. (2010a)	Panel	Population	Yes	−0.23
Fletcher et al. (2010b)	Panel	Adolescents	Yes	0.00
Fletcher et al. (2010c)	Panel	Adolescents	Yes	0.00
Schroeter et al. (2008)	Calibration	Households	Yes	−0.22
Sturm et al. (2010)	Panel	Adolescents	Yes	−1.00

Table 2: Results of policy simulations in Irz (2010).

	Decrease in FAH VAT	Decrease in FAFH VAT	Fat tax	Thin subsidy	Fat tax + thin subsidy
Macronutrients					
Energy	0.49%	−0.33%	−0.14%	0.06%	−0.04%
Proteins	0.63%	−0.05%	−0.05%	−0.05%	−0.16%
Fat	0.14%	−0.92%	−0.51%	−0.41%	−1.26%
Carbohydrates	0.49%	−0.26%	0.16%	0.43%	0.96%
Nutritionally relevant foods					
Sugar	0.26%	−1.39%	−1.07%	1.44%	1.60%
F&V	0.62%	0.26%	−0.48%	0.23%	−0.06%
Fresh F&V	0.75%	0.43%	−0.68%	0.26%	−0.20%
Food expenditure					
FAH	−2.55%	0.13%	1.31%	−0.77%	−0.11%
FAFH	1.89%	−1.67%	−0.93%	0.48%	−0.04%
Total	−1.33%	−1.21%	0.69%	−0.42%	−0.09%

Table 3: Demand elasticities used in simulations by Kotakorpi et al. (2011).

	bread	meat	fish	fr&veg	sweets&sug	others
bread	-0.726	0.319	-0.133	0.237	-0.283	0.575
se	0.277	0.119	0.083	0.074	0.198	0.319
meat	0.309	-0.025	-0.049	-0.302	0.203	-0.135
se	0.116	0.117	0.302	0.060	0.087	0.216
fish	-0.695	-0.264	-0.932	0.003	0.591	1.297
se	0.430	0.230	0.233	0.166	0.378	0.596
fr&veg	0.346	-0.439	0.001	-0.426	-0.119	0.637
se	0.104	0.087	0.045	0.099	0.083	0.237
sweets&sug	-0.542	0.404	0.219	-0.163	-2.538	2.621
se	0.381	0.174	0.140	0.113	0.557	0.576
others	0.017	-0.004	0.006	0.013	0.040	-0.074
se	0.009	0.007	0.000	0.005	0.009	0.019

Table 4: Demand elasticities used in simulations by Irz (2010).

System	Price						
	Good 1	Good 2	Good 3	Good 4	Good 5	Good 6	Expenditure
Stage 1							
FAFH	**−0.59**	−0.44	−0.10	−1.00			**2.14**
	(−2.4)	(−2.4)	(−0.8)	(−4.6)			**(7.7)**
FAH	−0.03	**−0.41**	−0.08	−0.21			**0.73**
	(−0.5)	**(−3.9)**	(−1.4)	(−1.9)			**(4.8)**
Nondurables	0.05	−0.16	**−0.33**	−0.47			**0.91**
	(0.8)	(−1.9)	**(−4.1)**	(−3.9)			**(5.6)**
Services	−0.06	−0.16	−0.16	**−0.60**			**0.98**
	(−2)	(−3.3)	(−5.1)	**(−8.7)**			**(11.5)**
Stage 31 (starches)							
Rice/other grains	**−0.20**	0.05	−0.09	0.13			**0.23**
	(−0.8)	(0.6)	(−0.6)	(0.4)			**(0.7)**
Potatoes	0.02	**−0.26**	−0.10	−0.11			**0.85**
	(0.4)	**(−3.5)**	(−2.6)	(−1.3)			**(2.7)**
Flour & groats	−0.07	−0.14	**0.06**	−0.11			**0.49**
	(−0.6)	(−2.5)	**(0.4)**	(−0.6)			**(1.9)**
Bread	0.02	−0.04	−0.03	**−0.26**			**0.58**
	(0.4)	(−1.2)	(−0.6)	**(−2.5)**			**(3.2)**
Stage 32 (meat)							
Fresh meat	**−0.26**	0.10	−0.04	0.01	0.09	−0.01	**0.84**
	(−2)	(0.8)	(−0.4)	(0.3)	(1.6)	(−0.5)	**(3.4)**
Sausages	0.13	**−0.62**	0.12	0.09	0.08	0.07	**0.87**
	(0.8)	**(−2.1)**	(0.6)	(1.1)	(1.2)	(2.2)	**(3.4)**
Processed meat	−0.13	0.16	**−0.23**	0.24	−0.18	−0.04	**1.37**
	(−0.6)	(0.5)	**(−0.7)**	(1.8)	(−1.8)	(−1)	**(3.5)**
Other meat prod.	0.12	0.57	0.94	**−1.57**	−0.09	−0.04	**0.50**
	(0.4)	(1.1)	(1.8)	**(−4.1)**	(−0.6)	(−0.7)	**(1.8)**
Fish	0.22	0.15	−0.20	−0.03	**−0.31**	0.04	**0.88**
	(1.7)	(1.2)	(−1.7)	(−0.7)	**(−2.9)**	(1.2)	**(2.9)**
Eggs	−0.07	0.37	−0.12	−0.04	0.13	**−0.36**	**0.64**
	(−0.4)	(2.3)	(−0.8)	(−0.7)	(1.2)	**(−4.8)**	**(2.1)**
Stage 33 (milk & dairy)							
Milk and powder	**−0.29**	−0.04	0.21	0.12			**0.44**
	(−1.9)	(−0.3)	(2.2)	(1.1)			**(2.7)**
Sour milk products	−0.10	**−0.21**	0.07	0.24			**0.66**
	(−0.4)	**(−0.6)**	(0.3)	(1.2)			**(2.6)**
Other dairy	0.44	0.07	**−0.45**	−0.05			**0.61**
	(2.1)	(0.3)	**(−1.9)**	(−0.3)			**(2.5)**
Cheese	0.15	0.14	−0.03	**−0.26**			**0.40**
	(1.1)	(1.2)	(−0.2)	**(−1.7)**			**(2.6)**
Stage 34 (fruits & vegetables)							
Fresh/frozen fruits	**−0.45**	−0.06	−0.02	0.02			**0.52**
	(−4.4)	(−2.2)	(−0.4)	(0.5)			**(2.2)**
Fruit preparations	−0.39	**−0.50**	0.03	0.04			**0.82**
	(−2.3)	**(−5)**	(0.3)	(0.4)			**(2.2)**
Fresh vegetables	−0.04	0.01	**−0.52**	0.06			**0.49**
	(−0.4)	(0.4)	**(−5.3)**	(1.5)			**(2.1)**
Vegetable prep.	0.07	0.02	0.14	**−0.61**			**0.38**
	(0.5)	(0.5)	(1.6)	**(−6.8)**			**(1.9)**
Stage 35 (foods high in fat/sugar)							
Cakes & pastries	**−0.54**	−0.04	0.08	−0.04	0.12		**0.88**
	(−3.9)	(−0.4)	(1.2)	(−0.7)	(1.6)		**(3.5)**
Butter	−0.10	**−0.37**	0.17	−0.07	−0.21		**1.21**
	(−0.5)	**(−1.5)**	(1.2)	(−0.5)	(−1.4)		**(2.6)**
Margarine & oils	0.31	0.28	**−0.55**	−0.07	0.18		**−0.32**
	(1.4)	(1.3)	**(−2.8)**	(−0.5)	(1.4)		**(−1.1)**
Sugar, honey, etc.	−0.10	−0.07	−0.07	**−0.38**	0.18		**0.89**
	(−0.6)	(−0.5)	(−0.7)	**(−2.6)**	(1.5)		**(2.6)**
Confectionary	0.14	−0.10	0.04	0.09	**−0.61**		**0.92**
	(1.6)	(−1.4)	(1)	(1.5)	**(−6.9)**		**(3.3)**
Stage 36 (beverages)							
Nonalcoholic	**−0.20**	0.02					**0.41**
	(−3.3)	(0.2)					**(1.9)**
Alcoholic	−0.03	**−0.37**					**(3.4)**
	(−1)	**(−3.2)**					**(3.4)**

Table 5: US price elasticity estimates for food and beverage category, from 1938-2007, as reported in Andreyeva et al. (2010).

TABLE 1—US Price Elasticity Estimates, by Food and Beverage Category, from 1938–2007

Food and Beverage Category[a]	Absolute Value of Mean Price Elasticity Estimate (95% CI)	Range	No. of Estimates
Food away from home	0.81 (0.56, 1.07)	0.23–1.76	13
Soft drinks	0.79 (0.33, 1.24)	0.13–3.18	14
Juice	0.76 (0.55, 0.98)	0.33–1.77	14
Beef	0.75 (0.67, 0.83)	0.29–1.42	51
Pork	0.72 (0.66, 0.78)	0.17–1.23	49
Fruit	0.70 (0.41, 0.98)	0.16–3.02	20
Poultry	0.68 (0.44, 0.92)	0.16–2.72	23
Dairy	0.65 (0.46, 0.84)	0.19–1.16	13
Cereals	0.60 (0.43, 0.77)	0.07–1.67	24
Milk	0.59 (0.40, 0.79)	0.02–1.68	26
Vegetables	0.58 (0.44, 0.71)	0.21–1.11	20
Fish	0.50 (0.30, 0.69)	0.05–1.41	18
Fats/oils	0.48 (0.29, 0.66)	0.14–1.00	13
Cheese	0.44 (0.25, 0.63)	0.01–1.95	20
Sweets/sugars	0.34 (0.14, 0.53)	0.05–1.00	13
Eggs	0.27 (0.08, 0.45)	0.06–1.28	14

Note. Values were calculated based on the 160 studies reviewed. Absolute values of elasticity estimates are reported. The price elasticity of demand measures the percentage change in purchased quantity or demand with a 1% change in price.
[a]Including restaurant meals and fast food.

Table 6: Elasticities of demand, quantity, and quality as reported in Reeds, Levedhal and Clark (2003), Table 2.

	Demand		Quantity		Quality	
Description	Elasticity	*t*-Value	Elasticity	*t*-Value	Elasticity	*t*-Value
Beef:						
Beef Price	-1.425	-8.22	-0.103	-0.54	-1.322	-5.16
Pork Price	-0.225	-1.39	0.313	0.94	-0.538	-1.46
Poultry Price	-0.094	-0.88	0.322	3.47	-0.416	-3.04
Other Meat Price	0.836	4.32	-1.317	-7.82	2.153	8.13
Income	0.908	8.59	-0.008	-0.10	0.916	7.52
Pork:						
Beef Price	-0.449	-1.66	0.052	0.21	-0.502	-1.60
Pork Price	-0.462	-1.01	0.032	0.07	-0.494	-0.93
Poultry Price	-0.082	-0.38	-0.974	-7.60	0.891	4.19
Other Meat Price	-0.179	-0.42	0.794	3.64	-0.972	-2.35
Income	1.172	5.97	-0.065	-0.67	1.238	6.50
Poultry:						
Beef Price	-0.292	-1.17	1.020	4.61	-1.311	-4.13
Pork Price	-0.111	-0.39	-1.635	-4.33	1.524	3.26
Poultry Price	-1.106	-3.67	-0.070	-0.70	-1.036	-3.53
Other Meat Price	0.302	0.69	0.494	2.74	-0.191	-0.43
Income	1.206	4.72	0.073	0.93	1.133	4.70

Table 7: Contributions of quality vs quantity growth to consumption growth.

Product group	Total growth 1995-2006			Relative contributions to consumption growth	
	Quality	Quantity	Consumption	Quality	Quantity
Ice-cream	11.6%	-0.1%	11.5%	101.3%	-1.2%
Fish	15.6%	3.4%	19.5%	80.1%	17.2%
Fruit	-16.0%	27.9%	7.4%	-215.5%	375.6%
Vegetables	20.9%	16.3%	40.6%	51.5%	40.1%
Potatoes	13.2%	4.9%	18.8%	70.5%	26.0%
Bread and cereals	11.3%	16.3%	29.4%	38.3%	55.5%

MTT CREATES VITALITY THROUGH SCIENCE

MTT REPORT 32

www.mtt.fi/julkaisut

MTT, FI-31600 Jokioinen, Finland
Tel. +358 29 5300 700, email julkaisut@mtt.fi