A carbon tax on meat could increase external costs

Abstract

Meat products are an example of substitutable goods with multiple misaligned externalities. This means that internalizing only one of the external costs, for example a carbon tax to mitigate climate change, could increase the total external costs, for example by increasing animal suffering or zoonotic disease risks. This article calculates a threshold social cost of animal welfare: if the social cost of animal welfare is higher than this threshold value, levying a carbon tax on meat will increase total external costs. To avoid this possibility, levying a flat tax (i.e. the same tax rate for all meat products) is recommended.

Keywords: carbon tax; animal welfare; externalities; meat; moral footprint

JEL classification: H23, Q18

Introduction

When substitutable goods have multiple externalities that are not aligned, internalizing the external costs of only one of the externalities with a Pigouvian tax can sometimes backfire and increase the total external costs. As this article shows, meat is a prime example: meat products such as chicken meat, pork and beef are substitutable in the sense that they have positive cross-price elasticities (Lusk & Tonsor, 2016). Beef has a five times higher climate change externality than chicken meat, measured in terms of the carbon footprint (Poore & Nemecek, 2018). But chicken meat has a 30 to 160 times higher animal welfare externality than beef, measured in terms of the moral footprint (Saja, 2013). And chicken meat production may impose higher public health risks than beef, from pandemic zoonotic disease risks such as bird flu (Dhama, 2013). Hence, the climate change externality is not aligned with the animal welfare and public health externalities. Due to the substitutability and misalignment, introducing a carbon tax on meat could shift consumer demand from beef to chicken meat, and this could increase the external costs of animal suffering or public health risks, perhaps even to such a degree that total external costs increase.

The carbon tax rate of meat depends on the carbon footprint of meat (measured in units of kg CO2-equivalents per kg meat product) and the social cost of carbon or SCC (measured in units of dollar per kg CO2-equivalents). As the carbon footprints and SCC are estimated in the literature (e.g. Poore & Nemecek, 2018; Wang e.a., 2019), recent estimates have been made for the carbon tax rates of meat

(e.g. Funke e.a., 2021; Errickson, Kuruc & McFadden, 2021). In contrast, reliable estimates of the social cost of animal welfare or SCAW (measured in dollars per unit of welfare impact) and the zoonotic disease footprint (the number of new pandemic zoonotic viruses created per kg of meat) are lacking. Therefore, the external costs of animal welfare and public health risks, and the corresponding optimal tax rates, are not yet been properly estimated. Instead of calculating these costs and footprints, this article calculates threshold values for the SCAW and animal welfare tax rates. If the SCAW is higher than this threshold value, a carbon tax increases the total external costs. Or in other words: if a carbon tax (but no animal welfare tax) is implemented, the SCAW should better not exceed this threshold value, or the external costs would increase.

The model

The carbon tax rate t_i^c of product i (chicken meat, pork or beef) is the percentage price increase:

$$t_i^c = \frac{CF_i.SCC}{p_i}$$

with CF_i the carbon footprint (kg CO2e per kg meat), SCC the social cost of carbon (dollar per kg CO2e) and p_i the retail price (dollar per kg edible meat). Similarly, the animal welfare tax rate can be written as

$$t_i^a = \frac{MF_i.SCAW}{p_i}$$

with MF_i the moral footprint (welfare impact per kg product) and SCAW the social cost of animal welfare (dollar per unit of welfare impact). Saja (2013) measured three moral footprints: the number of farmed animals killed per kg of meat, the days of shortened lifespan of farmed animals per kg of meat, and the days of animal suffering per kg of meat. The SCAW can therefore be measured in terms of dollars per animal killed, per day of shortened lifespan or per day of suffering. Note, importantly, that these moral footprints are species independent. That means for example that the killing of a cow, a pig or a chicken are assumed to be equally bad (and independent of e.g. the slaughter method), and during an average day, a cow, a pig and a chicken experience an equal amount of suffering.

If the consumption quantities without taxation are given by Q_i (kg per capita per year), the consumption quantities after introducing a carbon tax can be written as[1]

[1] For ease of calculation, only additive effects are assumed. The change in consumption is a first order approximation, i.e. linear in the tax rates. This assumption may be too strong, because the tax rates t_j^c may be large such that higher order terms become important.

$$Q_i' = Q_i\left(1 + \sum_{j=1}^{3} e_{ji} t_j^c\right),$$

with the price elasticities of demand e_{ji} given by the percentage change in consumption quantity of product i due to a percentage increase in the price of product j.

The external climate costs generated by a meat consumer, in absence of a carbon tax, are given by $E^c(Q) = \sum_{i=1}^{3} p_i t_i^c Q_i$. When a carbon tax is implemented, all climate costs are internalized, and hence the external climate costs become zero.[2]

The external animal welfare costs in absence of a carbon tax are $E^a(Q) = \sum_{i=1}^{3} p_i t_i^a Q_i$. After introduction of a carbon tax, the external animal welfare costs change according to:

$$\Delta E^a = E^a(Q') - E^a(Q) = \sum_i t_i^a \left(\sum_j Q_i p_i e_{ji} t_j^c\right) = \sum_i t_i^a r_i^c$$

with $r_i^c = \sum_j Q_i p_i e_{ji} t_j^c$ the relative climate cost change due to carbon taxation (equal to the climate cost change per percentage carbon tax). A carbon tax increases the external animal welfare costs when $\Delta E^a > 0$, or when the weighted moral footprint is positive:

$$MF_{weighted} \equiv \frac{r_{chicken}^c}{p_{chicken}} MF_{chicken} + \frac{r_{pork}^c}{p_{pork}} MF_{pork} + \frac{r_{beef}^c}{p_{beef}} MF_{beef} > 0.$$

This weighted moral footprint is the change in total moral footprint of all the meat products consumed by a consumer over a year, due to the carbon tax.

The total external costs before a carbon tax are given by $E^t(Q) = E^c(Q) + E^a(Q) = \sum_{i=1}^{3} p_i (t_i^c + t_i^a) Q_i$. After introduction of the carbon tax, these total external costs increase when $\Delta E^a > -\Delta E^c = E^c(Q)$. A short calculation gives:

$$\sum_i r_i^c t_i^a = \sum_i \left(\sum_j p_i Q_i e_{ji} t_j^c\right) t_i^a > \sum_i p_i Q_i t_i^c,$$

$$\sum_i r_i^c \frac{t_i^a}{t_{chicken}^a} \frac{t_{chicken}^a}{t_{chicken}^c} > \sum_i p_i Q_i \frac{t_i^c}{t_{chicken}^c},$$

$$\frac{t_{chicken}^a}{t_{chicken}^c} > \frac{\sum_i p_i Q_i \frac{t_i^c}{t_{chicken}^c}}{\sum_i r_i^c \frac{t_i^a}{t_{chicken}^a}} = \frac{\sum_i Q_i \frac{CF_i}{CF_{chicken}}}{\sum_i \sum_j Q_i e_{ji} t_j^c \frac{MF_i}{MF_{chicken}}},$$

[2] The new climate change costs $E^c(Q') = \sum_{i=1}^{3} p_i Q_i' t_i^c$ no longer represent external costs, but represent the carbon tax revenue that is sufficient to compensate for the climate damages.

$$SCAW = \frac{p_{chicken} t^a_{chicken}}{MF_{chicken}} > \frac{\sum_i Q_i CF_i}{\sum_i \sum_j Q_i MF_i e_{ji} t^c_j} SCC = \frac{\sum_i Q_i CF_i}{\sum_i \sum_j Q_i MF_i e_{ji} CF_j / p_j} \equiv SCAW_{threshold}.$$

The latter inequality defines the threshold social cost of animal welfare.

Data

Tables 1 and 2 show respectively the market values (for the US) and footprint values of the three meat products, which can be used in the above equations.

Table 1: Meat market variables

	Retail price	Elasticity of demand from beef price increase	Elasticity of demand from pork price increase	Elasticity of demand from chicken price increase	Consumption
	$/kg				kg/year/cap
	USDA Economic Research Service, Meat Price Spreads (2021)	Lusk & Tonsor (2016, Table 3), for middle income US citizens, average of meat product varieties (e.g. chicken breasts, chicken wings) weighted by market shares (Table 2)			USDA (2021)
Chicken	8	0,24	0,13	-0,67	45
Pork	9	0,34	-0,71	0,43	23
Beef	15	-0,74	0,16	0,38	27

Table 2: Climate change and animal welfare variables

	Climate change costs	Climate change costs	Carbon tax rate	Carbon footprint	Killed animals moral footprint	Shortened lifespan moral footprint	Suffering period moral footprint
	$/kg	$/kg	%	kg CO2e/kg	animals/kg	days/kg	days/kg
	Funke e.a. (2021)	Errickson, Kuruc & McFadden (2021)	Average of Funke e.a. (2021) and Errickson, Kuruc & McFadden (2021) relative to price	Poore & Nemecek (2018)	Saja (2013)	Saja (2013)	Saja (2013)
Chicken	0,5	0,9	9%	10	0,50	1734	68,5
Pork	0,6	1,4	11%	12	0,01	53	1,9
Beef	5,8	6,9	42%	71	0,003	20	2,2

The own-price elasticities of demand are around -0,7, which are very close to other values in the literature (Andreyeva, Long & Brownell, 2010). The average carbon tax rates of Funke e.a. (2021) and

Errickson, Kuruc & McFadden (2021) correspond with the carbon footprints of Poore & Nemecek (2018) when the SCC is $80 per ton CO2e, which is a reasonable value (Wang e.a.,, 2019).

Results

With the above values in tables 1 and 2, the weighted moral footprints can be calculated: 1,3 killed animals, 4522 days of shortened lifespan and 168 days of animal suffering per year. These values are the expected increases of animal welfare impacts over a year, caused by an average consumer, due to the carbon tax. For example, an average consumer will shift its diet towards chicken meat, such that the carbon tax results in an extra 168 days of animal suffering every year. Most importantly, these values are positive, which means that a carbon tax increases external animal welfare costs.

Table 3 shows further results: the climate change externality in the absence of the carbon tax, the demand change after introducing a carbon tax, and the threshold external costs corresponding to the three moral footprints. As expected, a carbon tax decreases the consumption of beef, the product with the highest carbon footprint, but increases the consumption of chicken meat and pork due to the positive cross-price elasticities.

Table 3: Threshold external animal welfare costs

	Climate change costs without carbon tax	Consumption change due to carbon tax	Threshold external cost of animal killing	Threshold external cost of animal shortened lifespan	Threshold external cost of animal suffering	Threshold animal welfare tax rate
	$/year/cap	kg/year/cap	$/kg	$/kg	$/kg	%
Chicken	32	2,62	86	87	92	1104%
Pork	23	2,39	2	3	3	25%
Beef	171	-7,11	1	1	3	10%

The threshold external costs of animal killing, shortened lifespan and duration of animal suffering of chicken meat are around 90 dollar per kg of meat, more than an order of magnitude larger than for pork and beef. If we value chicken welfare so much that the price of chicken meat should increase by more than 90 dollar per kilogram to internalize the animal suffering costs of chickens, then a carbon tax without an animal welfare tax would increase total external costs and decrease overall welfare. The threshold animal welfare tax rate of chicken meat is more than 1000%, corresponding with a tenfold price increase if such a tax was levied. This tax rate is two orders of magnitude higher than the carbon tax rate of chicken meat. In other words, if the external costs of animal suffering for chicken meat is

more than hundred times higher than the external costs of climate change from chicken meat production, a carbon tax would increase total external costs. This factor hundred threshold value might seem extreme, but remember that chicken meat has a relatively low carbon footprint and a relatively high moral footprint. We can look at beef instead: if the external costs of animal suffering for beef are more than a quarter higher than the external costs of climate change from beef production, a carbon tax would increase total external costs. In this case, the threshold of a quarter may seem less extreme.

It is difficult to say whether the threshold external costs of animal welfare are high or low. Table 4 shows estimated external costs of animal welfare according to a survey (Bruers, 2022). That survey asked people what they prefer in hypothetical situations, in particular how much money they would be willing to accept (WTA) to experience the life of a farmed animal instead of the life of a neutral animal (with a neutral welfare level), as well as how much money to would be willing to pay (WTP) to avoid experiencing the life of a farmed animal (and experience the life of a neutral animal instead). Those WTA and WTP values can be expressed in dollars per kilogram of meat, and can be interpreted as the external costs. As the table shows, the average WTA is four orders of magnitude higher than the average WTP. The threshold external costs calculated above, are between those WTA and WTP averages. Hence, whether the external costs are lower or higher than the threshold value, remains inconclusive.

Table 4: External costs of animal welfare according to a survey (Bruers, 2022)

	Average WTA ($/kg)	Average WTP ($/kg)
Chicken	50000	5
Pork	200	0,03
Beef	100	0,02

Table 5: Threshold social costs of animal welfare

Dollars per killed animal	172
Dollars per day of shortened lifespan	0,05
Dollars per day of suffering	1,3

The threshold social costs of animal welfare are given in Table 5. The first threshold level, the social costs per killed animal, can be compared with e.g. the value of a statistical life of a human, which is almost 10 million dollars (US DOT, 2016). If a farmed animal life is worth more than 0,002% of a human life in monetary terms, the social cost of animal welfare is above the threshold value and a carbon tax will increase the total external costs.

The third threshold level, the social costs per day of animal suffering, can be compared with the minimum amount of money an average human is willing to accept to compensate for that day of

suffering. For example Kuruc & McFadden (2021) arbitrarily assumed that a day of suffering of a farmed animal is equally bad as a day of suffering of a human who lives at an income of 1 dollar per day, and a neutral day with a zero welfare for an animal corresponds with a human living at the absolute poverty threshold (1,9 dollar per day). In this case, the loss of welfare of one day of the farmed animal can be compensated by increasing the welfare of humans, in particular by increasing the daily income of an average human with $80. Hence, with these assumptions, 80 dollars is the social cost of one day of animal suffering. This is much higher than the above calculated threshold value of 1,3 dollars per day of suffering.

Discussion

The above results do not account for three important considerations. First, there is the question whether cows, pigs and chickens experience the same levels of suffering in agriculture. This is under dispute: most people believe that broiler chickens have worse lives than beef cattle (for survey evidence, see Espinosa & Treich, 2021 and Bruers, 2022). This would imply that the moral footprint disparity between beef and chicken meat is larger than is assumed in the present study (remember that Saja's moral footprint, used in this study, assumed equal intensity of suffering of farm animals). That means that the shift from beef to chicken meat is more likely to increase external costs than is estimated in the present study.

Second, there is the problem of population ethics. Farm animals may experience suffering, but if they also experience happiness, and if that happiness trumps the suffering, then those farm animals have a net-positive welfare and have lives worth living. Eating more meat means breeding more animals, which means more days of net-positive welfare. The shift from beef to chicken meat could thereby increase total welfare. This is the famous 'logic of the larder' argument for meat consumption (Matheny & Chan, 2005). However, many population ethical theories that justify eating 'happy meat' (from farm animals with lives worth living), entail counter-intuitive implications (Bruers, 2022b). A proper calculation of the external costs of animal welfare, especially when farm animals have a net-positive welfare, requires first of all a choice of the desired population ethical theory (Arrhenius, 2000; Blackorby, Bossert & Donaldson, 2005; Greaves, 2017). The present study avoided this issue, because it implicitly assumed that animals have a net-negative welfare, i.e. lives not worth living (or more accurately: lives worth not living). Especially broiler chickens are assumed by most people to have lives not worth living (for survey evidence, see again Espinosa & Treich, 2021 and Bruers, 2022). If beef cattle would have net-positive lives whereas broiler chicken have net-negative lives, the moral footprint disparity between beef and chicken meat becomes even larger and the shift from beef to chicken meat becomes worse than is estimated in the present study.

A third consideration involves indirect effects of animal farming on animal welfare. Animal farming has an impact on nature and hence on wild animals. The agricultural ecological footprint, which measures land use, of beef is higher than the ecological footprint of pork and chicken meat (Wackernagel & Rees,1998; Poore & Nemecek, 2018). A shift from beef to chicken meat reduces agricultural land use. On the one hand, that means a reduction in the suffering and deaths of wild animals on agricultural land. But on the other hand, things get complicated when we take into account the animals born in nature. Compared to natural habitat, fewer wild animals are born on grazing land and cropland that is used for animal feed. A shift from beef to chicken meat frees up land that could be converted back to nature, where more wild animals are born. The welfare state of those wild animals is difficult to determine, but if some of those wild animals also have net-negative lives like broiler chickens (as argued by e.g. Ng, 1995), increasing the populations of wild animals increases animal suffering. Much more research in population ethics, animal sentience and welfare biology (Soryl e.a. 2021) are needed to estimate the external costs of wild animal suffering.

Conclusion

A carbon tax will probably increase the external costs of animal suffering (and probably also the external costs of new zoonotic diseases). It is not unlikely that the carbon tax could even result in an increase in total external costs. Especially if animal welfare is not discounted too much, if the social cost of animal welfare is for example higher than $200 per killed animal or $2 per day of suffering, total external costs could increase. To avoid this risk of increasing external costs, policymakers are recommended to levy a flat tax on all meat products, i.e. applying the same tax rate on beef, pork and chicken meat. With such a flat tax, the total external costs will decrease, even when meat products are substitutable, when externalities of climate change and animal welfare are not aligned and when the social cost of animal welfare is extremely high. If agricultural greenhouse gas emissions are included in an emission trading system (ETS), instead of a taxation, it is recommended to introduce a meat tax that captures the external costs of animal welfare and public health risks. As long as the social cost of animal welfare is not properly estimated and publicly accepted, the tax rate of chicken meat can be set equal to the price increase of beef from the ETS.

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