Miles and more: A quantitative assessment of the 'food miles' movement

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Abstract

One aspect of the climate change discussion that has attracted a great deal of media attention, particularly in Europe, is 'food miles'. The concept that the further food has to travel, the worse its impact on the environment is one that – although flawed – is easy for consumers to grasp and for domestic import-competing food producers to support. We investigate the economic implications of food miles-induced preference changes using an economy-wide analysis. We find that welfare losses relative to GDP are largest in New Zealand and several Sub-Saharan African nations. Moreover, for some distance-preference change relationships proportional welfare costs are significantly larger in parts of Sub-Saharan Africa than elsewhere.

Key words: food miles, computable general equilibrium modelling

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Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Ministry of Foreign Affairs and Trade.

1. Introduction

For those of you who know New Zealand, if we asked you to use one adjective to describe the capital city of Wellington, it probably wouldn't be 'warm'. Yet Wellingtonians are celebrating because it's been the warmest, longest summer in many years. Further North in the dairy-focused Waikato region, farmers are experiencing one of the worst droughts in decades and are praying for rain. Amongst the celebrations and consternations, many suggest that this unusual weather pattern is due to climate change and is a portent of things to come.

At the same time, New Zealand's national carrier, Air New Zealand, has announced that it will now provide its passengers with the option of paying *more* for their fares, despite receiving no tangible change in the quality of service provided. Passengers may, if they choose, pay an additional 'carbon offset charge' per flight that will be used by Air New Zealand to invest in green technology and reforestation programmes.[1] Meanwhile, from the other side of the World, a website has been developed to promote the 'Fife Diet' that aims to bring people together to eat good local food, boost the local community of food producers and help participants re-learn how to eat seasonally.[2] Finally, Walkers Crisps have announced that after a scientific analysis, they are happy to inform consumers that there is precisely 75 grams of embodied carbon dioxide in each packet of their cheese and onion flavoured crisps.[3]

The connection between these various snippets is that consumers, producers, governments and societies all around the globe are starting to pay much greater attention to the potential effects of climate change.[4] As awareness grows, the behaviour of these economic agents will change: they are already starting to take actions that they believe may lead to an improvement in the global environment. The weighting that environmental issues take in economic agents' behavioural decisions is increasing over time. These actions have subsequent economic consequences.

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[1] See www.airnz.co.nz/aboutus/mediacentre/pressreleases.
[2] See http://fifediet.wordpress.com.
[3] See http://www.walkerscarbonfootprint.co.uk/walkers_carbon_footprint.html.
[4] We do not attempt to review the screeds of literature on the science of climate change. While debate continues about the precise nature and drivers of changes to the global climate, this paper proceeds on the basis of a few broad, commonly-accepted assertions: the average global temperature is rising; that human activities have played a large part in this; that there are economic costs from both inaction and action; and that behavioural changes from economic agents are required over time to reduce our impact on the environment.

One particularly topical area of discussion in media and policy circles concerns the production, transportation and consumption of food. In this paper, we explore how changing consumer preferences, even when possibly ill-informed, could have relatively large impacts on food exporting nations, including developed countries such as New Zealand and developing countries such as those in Sub-Saharan Africa.

In particular, we focus on the concept of 'food miles' – crudely defined as the distance that food has to be transported from producer to consumer, and the associated greenhouse gases (GHG) emissions generated by that food transport. We investigate the economic consequences of a shift in preferences in three Western European nations – the UK, France and Germany – towards food transported shorter distances. Our simulations consider several different relationships between preference shifts and distance. In all specifications, we find that welfare losses relative to GDP are largest in New Zealand and several Sub-Saharan African nations.

For some distance-preference shift relationships, however, welfare losses in some Sub-Saharan nations are significantly larger than elsewhere. This is because, despite being geographically closer to the Europe than several developed countries, African nations such as Malawi export large amounts of agro-food products (relative to their GDP) to Europe. These results indicate that some of the world's poorest nations may bear the brunt of Europe's 'food miles' movement.

This paper has three further sections. The next section provides an overview of the food miles debate. Section 3 outlines our modelling framework and details results from our simulation exercises. The final section concludes.

2. Overview of the food miles debate

Historical context

The phrase 'food miles' was first coined by British academic Professor Tim Lang in the mid-1990s (Paxton, 1994). In the context of Lang's work on food consumption, transport and the environment, food miles was described as the distance that our groceries have to travel to reach our plates. The clear inference was that the further

food has to travel, the worse it is for the environment, due to the carbon emissions generated in the transport of the food.[5]

Over the next few years, the concept of food miles started to become more widely used, as a variety of economic agents embraced its simplicity when seeking to raise concerns about the environmental impacts of food production and consumption. This was all taking place at a time when many UK consumers were interested in trying to reduce their personal 'carbon footprint' – the amount of carbon dioxide they generate through living their daily lives.

By 2003-04, food miles was appearing on a daily basis across various media outlets in the UK. The message in these media articles was unambiguous: one easy way of reducing your carbon footprint is to reduce the amount of food in your diet that has travelled long distances. For example, these articles asked, why buy lamb imported 11,000 miles from New Zealand when a perfectly good substitute can be sourced from Wales? Why buy tomatoes freighted to the UK from Spain when similar fruit can be bought from British farms? And why buy Australian wine when you can find something similar from a source closer to home such as France or Italy?[6]

Our overview focuses on the food miles debate in the UK as the concept was seeded and has gained the most momentum in this nation. There is, however, growing awareness of food miles, and related concepts such as 'buy local' and sustainability, across Europe, especially France and Germany, and North America. A number of drivers can be identified which explain the rise in popularity in the UK of food miles as a concept:

1. *Emotional/historical drivers*

   Food security has always been a concern of some portions of society in the post-War era, due to the shortage of food available in the World Wars. There is thus reluctance in some quarters to become overly reliant on other countries

[5] 'Carbon emissions' is often used instead of 'greenhouse gas emissions' in this paper. Of course, carbon dioxide is just one of the harmful gases that are generated by producing and transporting food, and methane and nitrous oxide are particularly important for many agricultural producers.
[6] Interestingly, British wine was rarely suggested as an alternative.

for essential food items and that a shift to greater self-sufficiency in food production would be a good idea.[7]

2. *Protectionism/sentimental*

Farming associations have been at the centre of efforts to promote the purchase of locally-produced food (at supermarkets and at farmers' markets) over imported products. The Farmers' Weekly website launched a concerted food miles advertising campaign with the slogan "Local food is miles better" in 2006.[8] This campaign aimed to tap into the UK's long-standing emotional attachment to the rural sector, where farming is seen as a traditional lifestyle. This campaign has been labelled 'protectionism in disguise' by some New Zealand Ministers concerned about its impact on trade flows and global emissions.[9]

3. *Commercial*

Sensing that there was growing consumer awareness of the distance travelled by, and environmental impact of, food, some UK producers launched their own advertising campaigns highlighting the perceived environmental evils of imported food. One advert created by a UK dairy producer showed a picture of a rusting freight ship, belching smoke (portraying the pollution caused by transporting butter from New Zealand) alongside a picture of a cute, sun-drenched, thatched traditional farmers' cottage (ostensibly representing the way that butter is made in the UK). The caption asked readers why they would want to buy butter that's been transported 11,000 miles.[10] These adverts appear to be aimed at advancing market share rather than improving the environment.

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[7] See http://www.go-self-sufficient.com/ containing comments such as "in wartime, when the sea lanes were under attack, the country nearly starved."

[8] See http://www.fwi.co.uk/gr/foodmiles/index.html

[9] New Zealand's Trade Minister suggests "Calls for food miles to be used in fact contradict the goal of reducing global emissions and are often a thinly disguised appeal for self-interested protectionism". (See http://www.beehive.govt.nz/release/food+miles+claims+miss+target.) Also New Zealand's Agriculture Minister's comments that "[food miles] is being used in Europe by self interested parties trying to justify protectionism in another guise". http://www.progressive.org.nz/modules.php?name=News&file=article&sid=2405

[10] See http://www.foodanddrinkeurope.com/news/ng.asp?n=69206-dairy-crest-anchor-butter.

4. *Environmental*

   As the concept of food miles became more commonly used, environmental lobby groups and NGOs adopted the idea and suggested that households could reduce their carbon footprint by reducing their imports of foodstuffs and buying more locally produced items.[11] As we will outline shortly, this simple assertion is misplaced, but for households wanting to be seen to 'do their bit' to combat climate change, it seemed like a fairly obvious and easy thing to do.

A combination of these various drivers has resulted in food miles becoming an increasingly oft-used expression amongst UK media, consumers and retailers.

Catchy phrase, flawed concept

At first glance, the concept of food miles is intuitively appealing – the further food has to travel, the worse it is for the environment. More transport equals more energy use equals more emissions. But look a little deeper and the flaws in the concept are clear. As a result, environmentally-minded consumers are being misled if they are told that food miles will help them make fully informed purchasing choices.

First, by considering only the distance that food travels, food miles does not take into account the efficiency levels of various modes of transport. Different modes of transport have dramatically different energy costs: the energy used, and emissions generated, per tonne-kilometre of freight depends on whether food is moved using aeroplanes, ships, trains, heavy goods vehicles, light goods vehicles or even household cars. For example, according to Smith *et al.* (2005, 2005, Table A3.1, Annex 3; also DEFRA, 2001; Mason *et al*, 2002) carbon emissions from long haul air freight are estimated to be over 100 times larger than those from sea freight. Therefore, ceteris paribus, air-freighted food will have a far higher environmental impact than sea freighted food. This is important for New Zealand, as 99.75% of its food and beverage exports to UK are sent by sea, rather than by air.

Second, and more importantly, the concept of food miles is over simplistic in that it focuses solely on the transport component of a product's entire life-cycle as a measure

[11] Saunders *et al.* (2006, p4) note that "The Women's Environmental Network went as far as to say that importing apples from New Zealand is 'insanity'".

of its environmental impact. This focus on transport ignores the energy used and emissions generated across the rest of the product's life cycle (during the planting, harvesting, storage, processing, packaging, disposal, etc).

Various studies have shown that food miles as a credible measure of environmental costs simply doesn't stand up to analytical scrutiny. DEFRA (2005, p.v) notes that it can be more sustainable (in energy terms) to import tomatoes from Spain than to produce them in heated greenhouses in the UK outside summer months. Saunders *et al.* (2006) estimate that, even after taking into account transport to the UK, the energy use associated with importing dairy products, lamb, apples and onions from New Zealand is lower than that associated with alternative sources. A German study (Schlich and Fleissner, 2003) has also compared New Zealand and German lamb production and concludes that when energy use in the production phase is taken into account, New Zealand lamb has lower energy inputs than lamb produced in Germany. So "the most popular claims for regional food production and distribution instead of global process chains are not generally valid….ecological quality is mainly influenced by operational efficiency and not by…distance itself" (insert page number). A report by Williams (2006) estimates that the carbon emissions associated with importing Kenyan roses into the UK were almost six times lower than for roses imported from the Netherlands, even after the emissions associated with air-freighting them from Kenya are considered. This is because of the very high emissions generated in the Netherlands by artificially heating and lighting roses, relative to those involved in growing roses in the Kenyan sunshine.

Other research has confirmed that the vast majority of transport distance and environmental costs associated with food supply are domestically generated, rather than attributable to international freight. DEFRA (2005) reports that 82% of vehicle kilometres associated with transporting food consumed in the UK are generated within the UK. Pretty *et al*. (2005) calculate that the environmental costs of freighting food by sea and air are 'trivial' compared with the costs of domestic food transport in the UK. They estimate that the externality cost of imported food is 0.005 pence per person per week in the UK. The externality cost of UK domestic road transport (from

farm to shop), in contrast, is 75.7 pence. The externality cost of transporting food from the shop to consumers' homes is 41.1 pence.[12]

This research has gone some way to highlighting that food miles (a single indicator based only on distance travelled) is an inadequate indicator of sustainability (DEFRA, 2005, p.ii). Indeed, in some circumstances, buying locally produced food can be more damaging to the environment than importing similar products from distant sources.

There is little evidence to suggest that other products have been heavily targeted by the concept, although 'wood miles' and 'flower miles' have appeared occasionally in overseas media publications. There is no logical economic reason why food should be singled out. The concept of 'flower miles', largely aimed at African flora, highlights another important aspect of the food miles debate. Developing countries are often heavily reliant on exports of primary products, and many are located far away from their key markets. A reduction in UK purchases of items from developing countries due to concerns over food miles or flower miles could have a significant detrimental effect on niche horticultural exports from these countries. Kenya has already expressed its concern about this possibility.[13]

Current tends

For the reasons outlined above, it is generally accepted in policy, academic and informed media circles that food miles is not a good indicator of environmental sustainability. Increasingly the issue has evolved to recognise the importance of considering the embedded greenhouse gases (GHG) across the entire life cycle of a product (also known as a GHG or carbon footprint) when trying to examine the environmental impact of food production and consumption.

This makes life difficult for the average UK consumer. If they are to make informed choices, they would need to know the GHG footprint of all of the products available

[12] Along similar lines, it has been estimated that a standard British shopping trip of 6.4 kilometres in a large family car to collect 20kg of food uses 25.6 megajoules of energy. This is the same amount of energy as is used to transport 20kg of food over 8,500 kilometres by sea (Heyes and Smith, 2006, p.2).

[13] See http://grownunderthesun.com/ The campaign's aim was to label all Kenyan horticultural exports to Europe with a sticker noting that they were "Grown under the sun" (i.e. with very little use of emissions-intensive inputs), although funding problems have since halted the campaign's progress (see http://allafrica.com/stories/200804031059.html).

to them, and then weigh up this environmental cost against other factors such as price, freshness, quality and seasonality. Some UK retailers (Tesco's in particular) have already started to investigate options for labelling food with some form of 'carbon label' that would present this information. They have quickly realised that this is a massive undertaking that requires a considerable amount of scientific research.[14] One of the major problems is that there is no commonly-agreed, robust methodology for conducting life cycle analyses.[15]

Regardless of these methodological problems, surveys and media reports from the UK suggest that consumers are increasingly aware of the potential environmental impacts of their food purchasing decisions, and are seemingly looking to purchase more locally-grown food. For example, Fishburn Hedges, a UK communications agency, conducted a survey in May 2007 and found that around 56% of UK consumers are aware of the phrase 'food miles' (Fishburn Hedges, 2007). Furthermore, a survey of 55,000 teenagers in the UK suggests that 40% had bought locally produced food instead of imports.[16]

On the retail side, "shopping trends at Waitrose show a clear demand from consumers for greener products. Sales of locally sourced produce, which come with fewer food miles, have risen 80% this year compared with last year" (UK Times, 2 December 2007). And in March 2008, Tesco reported that fresh produce labelled as local has seen a 20-25% uplift, compared to before the branding was launched.[17] There is also a small, but growing, awareness of the idea of having a low carbon or 'low impact' diet that includes fewer meat and dairy products (two of New Zealand's major exports to the UK), which are seen as being emissions-intensive to produce. Based on these factors, it seems reasonable to expect that there will be a shift in consumer preferences

[14] See http://www.guardian.co.uk/environment/2007/jan/25/supermarkets.ethicalliving which notes "Tesco freely admitted that it doesn't know how to measure this [carbon footprint] yet, and has effectively outsourced the problem to scientists at Oxford's Environmental Change Institute, along with the promise of £5m funding to help them along. The problem for Tesco's grand announcement is that Brenda Boardman, who leads the institute, is in the dark too. "I don't know how we'll do this either yet. We haven't started and it's not going to be an easy project," she said".

[15] Note however, that DEFRA, The Carbon Trust and British Standards Institute are working collaboratively to develop a Publicly Available Specification (essentially a standard) for measuring the GHG footprint of goods and services. This may, in time, be a basis for moves towards widespread retailer carbon labelling.

[16] See http://www.forumforthefuture.org.uk/future/test_head_page499.aspx.

[17] See In Fresh Produce Journal (Insert reference).

away from imported food towards locally-produced products, although determining the timing and size of this shift is difficult.[18]

New Zealand clearly has a significant interest in how these debates develop, for the following reasons:

- Despite the New Zealand economy diversifying in recent decades, the primary sector remains central to New Zealand's economic prospects.
- Over 50% of New Zealand's merchandise exports are related to food and beverages.
- The UK accounts for over $1 billion of food and beverage exports.
- Inbound tourism is also an important source of export earnings (around as large as the New Zealand dairy export sector) and could also be negatively affected if consumers start to avoid long-haul air travel due to concerns over the GHG emitted during these flights.

Furthermore, although some have suggested that 'distance is dead' (Cairncross, 1997), there is no escaping that New Zealand is the most geographically distant developed country from the UK. Any goods transported from New Zealand must travel a long way to market. And some of these exported goods compete with domestically-produced items and/or similar items transported shorter distances, such as lamb, apples and dairy products. Therefore New Zealand has tended to be portrayed as the 'poster child of food miles' – if a journalist is looking to run a story along the lines of "Why buy good X from far-away country Y when you could buy something similar that is produced in the UK and thus reduce food miles?", then New Zealand has often been used as Country Y.

Should this rather unwelcome attention to New Zealand be translated into real changes in consumer or retailer behaviour, then there is potential for New Zealand's export interests to be affected. This could happen either through the volume channel

[18] While environmental factors are becoming more important in consumers' purchasing decisions, factors such a price and quality still dominate (Fishburn Hedges, 2007, p.11).

(UK consumers wanting to buy less from New Zealand due to feelings of guilt about the environment impacts of such purchases) or the price channel (major retailers using potential New Zealand vulnerability to food miles concerns as leverage in price negotiations with New Zealand exporters). As a result, food miles has become a fairly delicate and important issue for New Zealand exporters over the past two years in particular, and they have sought to respond to these emerging market signals.

3. Modelling exercises

We analyse the impact of European food miles movements in the UK, France and Germany using an economy-wide analysis. Our chosen model, 'GTAP6inGAMS', draws on the Global Trade Analysis Project (GTAP) database (Dimaranan, 2006) and is programmed using the General Algebraic Modelling System (GAMS) software. GTAP6inGAMS is a global model that captures both inter-sectoral linkages within regions and economic linkages between regions. As the model is well know and outlined in detail by Rutherford (2005), we do not discuss it here.

Version 6 of the GTAP database identifies 87 regions and 57 commodities. We aggregate the database to form 15 regions and 14 sectors. The composition of regions and sectors identified in our model in terms of components recognised in the GTAP database are highlighted in Table 1. Our regional aggregation identifies New Zealand, several Sub-Saharan African regions, countries with active food miles campaigns (the UK, France and Germany), and other nations. Our treatment of Sub-Saharan African nations singles out Madagascar and Malawi as European food miles movements are likely to have a significant impact on these nations.[19] To highlight this point, we display agro-food exports relative to GDP in Table 2. The data reveal that agricultural exports to the UK are most important for (in descending order) Malawi (1.88% of GDP), Rest of South African CU (1.27%) and New Zealand (1.10%). With respect to France, Madagascar's agro-food exports to this market relative to GDP are high (3.08%), while moderate numbers are reported for Malawi (0.76%) and Rest of sub-Saharan Africa (0.57%). Germany, on the other hand, is a relatively important export market for Malawi (3.10%) and New Zealand (0.72%).

[19] It also appears that other African nations, such as Kenya, will be large losers following European food miles campaigns. Unfortunately, the current aggregation of the database does not allow us to identify these nations separately.

Turning to the column for all active nations, significance measures are considerably higher for Malawi and Madagascar, 5.73% and 3.42% respectively, than those for other nations. Moderately high numbers are observed for New Zealand (2.15%), Rest of South African CU (1.91%) and Rest of Sub-Saharan Africa (1.62%). Overall, the data indicate that agro-food exports to active nations are more important for several Sub-Saharan African countries than most other countries. This suggests that, despite New Zealand's geographic isolation, food miles welfare losses may be most severe in some of the world's poorest nations.

In our sectoral aggregation, non-food manufacturing and services each enter in aggregate sectors and we identify agro-food commodities that are significant export earners for countries likely to experiences large losses as a result of food miles-related preference changes. To elaborate, Table 3 reports agricultural exports to active nations by product category relative to total agricultural exports for each country. Focusing on countries likely to experience the largest losses from food miles movements, New Zealand's major agro-food exports to active nations include meat products (50.8%), vegetables and fruit (18.6%) and dairy products (13.2%); Madagascar's exports are largely made up of other food products (70.8%), vegetables and fruits (14.9%) and other crops (12.2%); and Malawi's agro-food exports are dominated by other crops (85.9%).

We quantify the influence of European food miles lobbying using an 'iceberg' specification. That is, we assume a proportion of agro-food commodities exported to active countries melt during transportation. This specification has two interpretations relevant for our analysis. First, the amount of the product that melts can be taken as the amount of resources producers must use to persuade consumers to buy the product after the implementation of food miles campaigns. Second, melting can be interpreted as a quality-adjustment by consumers in active countries. That is, following the introduction of a food miles campaign, consumers in active countries might value, say, one foreign kiwifruit at 80% of the value of a pre-food miles kiwifruit.

As noted above, there is a large amount of uncertainty regarding how consumer preferences may change due to food miles campaigns. To make headway, we employ a flexible-form iceberg specification, as detailed in equation (1).

$$\lambda_r^s = \alpha + \beta d_r^{s\,\rho} \tag{1}$$

where λ_r^s is the proportion of exports from region *r* to active region *s* that melts during transportation (applied uniformly to all agro-food commodities), d_r^s is the distant between region *r* and active region *s*, and α, β and ρ are positive parameters. This specification allows us to model several different preference shift-distance relationships.

To measure distance, we employ harmonic-mean weighted distance measures available from the Centre D'Etudes Prospectives et D'Informations Internationales (CEPII).[20] Guided by Head and Mayer (2002), CEPII calculate bilateral distance between two countries as population-weighted average distances between the major cities belonging to those two countries. For distances between target and composite regions in our analysis, such as Rest of Sub-Saharan Africa and Rest of World, we calculate GDP-weighted averages of distances between each composite nation and target nations.

Table 4 reports distances between regions identified in our analysis and active countries. The data highlight Australia's and, in particular, New Zealand's isolation from Europe. Nearly 19,000 kilometres separates New Zealand from active nations. Distances between South Africa, Rest of South African CU, Madagascar and Malawi and active nations are about half those for New Zealand, but these nations are geographically disadvantaged in European markets relative to the US, Rest of Sub-Saharan Africa, the EU and Rest of World.

In our simulation exercises, we examine preference changes in active nations individually and as a group. In our base simulations, we calculate iceberg transport

[20] See http://www.cepii.fr/anglaisgraph/bdd/distances.htm.

cost by setting α equal to zero, ρ equal to one and calibrate β so that $\lambda^{s}_{New\ Zealand}$ is equal to 0.8.[21] As New Zealand is the region most isolated from all active regions, the fraction of exports to active countries from other regions melting during transportation is less than 0.2.

We measure welfare changes using Hicksian equivalent variation in income, which allows us to quantify the impact of shocks in monetary terms. Reported welfare changes are increments to welfare that can be expected in each and every succeeding year as a result of the relevant shock. Equivalent variation in 2001 US dollars and equivalent variation as a fraction of GDP are reported in Tables 5 and 6 respectively.

In all simulations, Japan, South East Asia and Rest of EU experience welfare improvements. Two forces drive this result. First, relative to other regions, especially in the case of Rest of EU, food miles campaigns increase the competiveness of exporters in active regions relative to exporters in other regions. Second, imports become cheaper as exports from other nations are diverted away from active countries.

Ignoring welfare changes in active countries, New Zealand (-0.299), Malawi (-0.279) and Madagascar (-0.119) experience the largest welfare decreases relative to GDP when our food miles shock applies to all nations. As noted above, this result is a function of (a) the distance between these nations and European markets, and (b) the importance of agro-food trade to these economies. Rest of South African CU (-0.069) and Rest of Sub-Saharan Africa (-0.044) also experience relatively large welfare reductions.

Turning to results when our food miles shock is applied to each active country individually, New Zealand experiences the largest welfare loss, relative to GDP, from the UK food miles shock (-0.149) and a relatively large welfare decline following the German food miles shock (-0.101). Malawi's largest welfare decline occurs for the German food miles shock (-0.168) and Madagascar's welfare decline is almost

[21] In our 'all active nations' simulations we calibrate β so that the iceberg parameter applying to New Zealand's exports to France (the most distant market) is equal to 0.8.

entirely driven by the French food-miles shock (-0.098). These findings concur with our qualitative conclusions regarding the relative importance of each active country's market to distant agro-food exporters.

Our base simulations assumed that preference changes were equal across agro-food commodities. It is, however, possible that consumers will apply the food miles concept in a discriminatory fashion across commodities. Accordingly, we consider two alternative cases. First, as European marketing campaigns have focused on the distant travelled by imported meat and dairy products, we consider food-miles preference changes in meat and dairy in isolation. Welfare changes relative to GDP, reported in Table 7, reveal that New Zealand is by far the largest loser from such a change in preferences and welfare changes in this nation are similar to those when our food miles shock is applied to all commodities. In all variants of the simulations, New Zealand exports of meat and dairy to active nations decrease by around 75%, and exports of these commodities to all other regions increase. When there are preference changes in all active countries, New Zealand output of meat products falls by about 11% and there is little change in dairy production. Elsewhere, Madagascar and Malawi are largely unaffected by the shock and Rest of South African CU experiences a moderate welfare loss.

A second possible discriminatory change in preferences could occur if consumers' perceptions of environmental damage from imported food differed across transport types. Air transportation is many times more carbon intensive that sea transportation, as noted above. Products transported by air in the 'food miles' spot light included flowers and some types of fruits and vegetables. To gain an appreciation of the impact of discriminatory treatment of transport modes, we assume that the fraction of 'other crops', which includes cut flowers and many other perishable items, that melts during transportation is twice as large as that for other agro-food products when implementing the shock in our base simulation.[22] Table 8 reports welfare changes relative to GDP. When there are preference changes in all active countries, the decrease in New Zealand welfare is similar to that in our base simulation, but the

[22] Our sectoral aggregation is not well suited to singling out food products largely transport by air. A detailed investigation would require disaggregation of GTAP's vegetables, fruits and nuts, and other crops sectors.

decrease in Malawian welfare is nearly twice as large as that in Table 6. Moreover, Malawi's proportional welfare decrease is significantly larger than that for New Zealand, or any other nations. Welfare reductions for Madagascar and Rest of Sub-Saharan Africa are also moderately larger in Table 8 than in our base simulations.

Alternative preference changes

So far we have assumed that consumers relate distance to food miles arguments in a linear fashion. It is possible, however, that consumers in active countries may develop an anti-import stance that is similar across sources. Alternatively, consumers may adopt the view that environmental damage from food transportation rises at an increasing rate as distance increases. To gauge the impact of alternative preference changes, we report welfare changes relative to GDP when we vary the values of α and ρ, when there is food miles-related preference changes in all active nations. Throughout our analysis, we stipulate that 20% of New Zealand's exports to active nations melt by varying the value of β.

Table 9 displays results for alternatives value of α when ρ is fixed at one. By design, results in the second column ($\alpha = 0$) are identical to those in the final column of Table 6. As α increases, food miles-related preference shifts are more similar across countries and when $\alpha = 0.2$ all nations face the same iceberg costs. The numbers reveal that, as might be expected, welfare decreases in geographically distant countries are reduced as α increases. Consequently, for relatively small values of α the welfare loss in Malawi, relative to GDP, is larger than that in New Zealand. Increasing α also increases the relative welfare loss in Rest of Sub-Saharan Africa, which is relatively close to active countries.

Welfare changes for alternative values of ρ when α is fixed at zero are reported in Table 10. The impact of distance on iceberg transport costs is positively related to ρ. Consequently, welfare losses in Sub-Saharan African nations are magnified as ρ decreases and for certain values of ρ the proportional decrease in welfare in Malawi is larger than that for New Zealand.

4. Conclusions

This paper considers the impact of changes in preferences in several European countries away from imported agro-food commodities. We implemented food miles shocks in the UK, France and Germany as food miles campaigns are most active in these nations. The impact of food miles movements on other nations depends on the importance of agro-food commodities to each economy and each nation's distance from Europe. Although there is some uncertainty concerning the nature of food miles-induced preference changes, the largest losers from declining demand for imported food, in a relative sense, will likely be New Zealand and several Sub-Saharan African nations, including Malawi and Madagascar. With the exception of New Zealand, this finding indicates that some of the world's poorest nations will suffer the most from European food miles lobbying. Furthermore, due to the relatively large proportion of African agro-food commodities transported by air, we found that welfare losses in Sub-Saharan Africa may be particularly severe if declines in European preference are largest for agro-food commodities imported using carbon-intensive transportation modes.

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Table 1: Regional and commodity aggregation

	Regions		Commodities
1.	**New Zealand**	1.	**Vegetables, fruits and nuts**
2.	**Australia**	2.	**Animal products**
3.	**United States**		Bovine cattle, sheep and goats, horses; animal products not elsewhere classified (nec)
4.	**Japan**	3.	**Raw milk**
5.	**South East Asia**	4.	**Wool**
	China, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand, Vietnam, Rest of South East Asia	5.	**Other crops**
		6.	**Other agriculture**
			Paddy rice; wheat; cereal grains; oil seeds; sugar cane, sugar beet; plant-based fibres; fishing
6.	**South Africa**	7.	**Meat products**
7.	**Rest of South African Custom Union**		Bovine meat products; meat products nec
	Botswana, Rest of South African Customs Union	8.	**Dairy products**
8.	**Madagascar**	9.	**Other food products**
9.	**Malawi**	10.	**Miscellaneous food products**
10.	**Rest of Sub-Saharan Africa**		Vegetable oils and fats; processed rice; sugar; beverages and tobacco products
	Botswana, Mozambique, Tanzania, Zambia, Zimbabwe, Rest of South African Development Community, Uganda, Rest of Sub-Saharan Africa	11.	**Forestry**
		12.	**Resource based sectors**
11.	**United Kingdom**		Coal; oil; gas; minerals nec
12.	**France**	13.	**Other manufacturing**
13.	**Germany**		Textiles; wearing apparel; leather products; wood products; paper products, publishing; petroleum, coal products; chemical, rubber, plastic products; mineral products nec; ferrous metals; metal nec; metal products; motor vehicles and parts; transport equipment nec; electronic equipment; machinery and equipment nec; manufacturing nec
14.	**Rest of EU**		
	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, , Latvia, Lithuania, Luxemburg, Malta, Netherlands, , Poland , Portugal, Slovakia, Slovenia, Spain, Sweden		
15.	**Rest of World (ROW)**	14.	**Services**
	All other regions		Electricity; gas manufacture, distribution; water; construction; trade; transport nec; water transport; air transport; communication; financial services nec; insurance; business services nec; recreational and other services; public administration, defence, education, health; dwellings

Table 2: Agro-food exports to active countries relative to GDP, %

	UK	France	Germany	All active
New Zealand	1.10	0.33	0.72	2.15
Australia	0.19	0.04	0.06	0.29
United Sates	0.01	0.00	0.01	0.03
Japan	0.00	0.00	0.00	0.00
South East Asia	0.04	0.03	0.06	0.13
South Africa	0.44	0.12	0.19	0.75
Rest of South African CU	1.27	0.45	0.19	1.91
Madagascar	0.05	3.08	0.29	3.42
Malawi	1.88	0.76	3.10	5.73
Rest of Sub-Saharan Africa	0.63	0.57	0.41	1.62
United Kingdom	-	0.10	0.06	0.16
France	0.26	-	0.32	0.58
Germany	0.10	0.15	-	0.25
Rest of EU	0.32	0.36	0.59	1.28
Rest of World	0.08	0.07	0.10	0.25

Source: GTAP 6 Database (Dimaranan 2006)

Table 3: Agricultural exports to the UK, France and Germany by product relative to total agricultural exports, %

	Vegetables etc	Animal products	Raw milk	Wool	Other crops	Other agriculture	Meat products	Dairy products	Other food products	Misc food products
New Zealand	18.6	2.4	0.0	6.3	0.5	0.2	50.8	13.2	2.6	5.5
Australia	2.9	1.9	0.0	14.6	1.0	4.5	11.6	4.8	4.3	54.6
United Sates	16.7	7.3	0.0	0.1	14.3	11.9	4.0	1.6	22.8	21.3
Japan	1.9	18.2	0.0	0.1	10.1	5.0	13.4	1.0	38.1	12.4
South East Asia	8.4	8.3	0.0	0.1	23.0	4.8	12.7	0.1	29.6	12.9
South Africa	55.0	0.9	0.0	2.3	8.6	0.8	2.7	0.1	6.7	22.9
Rest of South African CU	3.6	1.6	0.0	0.2	0.9	0.8	47.8	0.2	12.1	32.7
Madagascar	14.9	0.4	0.0	0.0	12.2	0.5	0.0	0.0	70.8	1.3
Malawi	1.2	0.1	0.0	0.0	85.9	0.9	0.0	0.0	0.4	11.5
Rest of Sub-Saharan Africa	19.7	1.2	0.0	0.1	40.9	5.0	1.0	0.1	20.9	11.0
United Kingdom	1.2	3.5	0.0	0.3	2.7	8.1	10.3	7.6	35.1	31.2
France	9.8	2.0	0.0	0.0	2.1	9.5	11.7	12.4	21.1	31.2
Germany	2.7	2.1	0.0	0.1	3.8	3.2	14.3	12.3	42.4	19.1
Rest of EU	16.8	2.9	0.0	0.1	7.3	2.8	17.4	10.6	26.6	15.4
Rest of World	19.7	3.2	0.2	0.5	14.5	12.0	6.7	2.2	29.2	11.7

Source: GTAP 6 Database (Dimaranan 2006).

Table 4: Distances between regions, kilometres

	United Kingdom	France	Germany
New Zealand	18,521	18,894	18,220
Australia	16,602	16,513	15,935
United Sates	6,878	7,457	7,595
Japan	9,436	9,803	9,086
South East Asia	9,295	9,427	8,771
South Africa	9,489	8,770	9,111
Rest of South African CU	8,675	8,313	8,480
Madagascar	9,265	8,582	8,666
Malawi	8,204	7,492	7,701
Rest of Sub-Saharan Africa	5,996	5,867	5,902
United Kingdom	-	750	809
France	750	-	790
Germany	809	790	-
Rest of EU	1,277	1,049	1,008
Rest of World	6,128	6,182	6,262

Source: Based on distance data from http://www.cepii.fr/anglaisgraph/bdd/distances.htm.

Table 5: Global welfare changes (equivalent variation, 2001 US dollars, million)

	UK	France	Germany	All active
New Zealand	-67.3	-21.4	-45.5	-135.4
Australia	-44.4	-13.7	-19.2	-76.0
United Sates	-280.5	-81.2	-129.5	-486.6
Japan	66.4	23.1	39.6	128.1
South East Asia	133.7	29.8	29.5	193.4
South Africa	-9.8	-1.5	-5.3	-15.9
Rest of South African CU	-5.7	-1.2	-0.1	-6.8
Madagascar	-0.4	-4.4	-0.6	-5.4
Malawi	-1.2	-0.7	-2.7	-4.4
Rest of Sub-Saharan Africa	-29.1	-27.4	-22.2	-77.4
United Kingdom	-1655.6	-10.6	-16.0	-1657.5
France	67.4	-855.8	28.3	-766.6
Germany	68.2	26.1	-1446.0	-1308.6
Rest of EU	148.2	65.7	147.3	358.1
Rest of World	-43.0	-66.4	-105.6	-208.3

Source: Authors' simulations as described in the text.

Table 6: Global welfare changes (equivalent variation as a fraction of GDP, %)

	UK	France	Germany	All active
New Zealand	-0.149	-0.047	-0.101	-0.299
Australia	-0.014	-0.004	-0.006	-0.023
United Sates	-0.003	-0.001	-0.001	-0.005
Japan	0.002	0.001	0.001	0.004
South East Asia	0.006	0.001	0.001	0.008
South Africa	-0.010	-0.001	-0.005	-0.016
Rest of South African CU	-0.057	-0.012	-0.001	-0.069
Madagascar	-0.008	-0.098	-0.014	-0.119
Malawi	-0.073	-0.042	-0.168	-0.279
Rest of Sub-Saharan Africa	-0.017	-0.016	-0.013	-0.044
United Kingdom	-0.125	-0.001	-0.001	-0.125
France	0.006	-0.074	0.002	-0.066
Germany	0.004	0.002	-0.087	-0.079
Rest of EU	0.004	0.002	0.004	0.011
Rest of World	-0.001	-0.001	-0.002	-0.004

Source: Authors' simulations as described in the text.

Table 7: Global welfare changes (equivalent variation as a fraction of GDP, %), preference changes for meat and dairy products

	UK	France	Germany	All active
New Zealand	-0.108	-0.045	-0.072	-0.227
Australia	-0.003	-0.001	-0.002	-0.006
United Sates	-0.001	0.000	-0.001	-0.002
Japan	0.001	0.000	0.000	0.001
South East Asia	0.002	0.001	0.001	0.004
South Africa	0.002	0.000	0.001	0.003
Rest of South African CU	-0.058	-0.003	-0.004	-0.064
Madagascar	-0.002	-0.001	-0.001	-0.004
Malawi	0.001	0.000	0.000	0.001
Rest of Sub-Saharan Africa	-0.002	-0.001	-0.001	-0.004
United Kingdom	-0.031	0.000	0.000	-0.031
France	0.001	-0.012	0.001	-0.010
Germany	0.001	0.001	-0.017	-0.014
Rest of EU	0.001	0.000	0.000	0.001
Rest of World	0.000	0.000	0.000	0.000

Source: Authors' simulations as described in the text.

Table 8: Global welfare changes (equivalent variation as a fraction of GDP, %), double preference changes for other crops

	UK	France	Germany	All active
New Zealand	-0.149	-0.047	-0.101	-0.300
Australia	-0.014	-0.004	-0.006	-0.024
United Sates	-0.003	-0.001	-0.001	-0.005
Japan	0.002	0.001	0.001	0.004
South East Asia	0.006	0.001	0.001	0.008
South Africa	-0.013	-0.002	-0.006	-0.020
Rest of South African CU	-0.055	-0.011	0.000	-0.066
Madagascar	-0.008	-0.112	-0.017	-0.138
Malawi	-0.132	-0.077	-0.327	-0.532
Rest of Sub-Saharan Africa	-0.023	-0.021	-0.020	-0.064
United Kingdom	-0.133	-0.001	-0.001	-0.133
France	0.006	-0.078	0.003	-0.070
Germany	0.004	0.002	-0.098	-0.089
Rest of EU	0.005	0.002	0.006	0.013
Rest of World	-0.001	-0.002	-0.003	-0.006

Source: Authors' simulations as described in the text.

Table 9: Equivalent variation as a fraction of GDP for alternative values of α when there are food miles changes in all active nations, % (ρ = 1)

	α					
	0	**0.04**	**0.08**	**0.12**	**0.16**	**0.20**
New Zealand	-0.299	-0.273	-0.241	-0.204	-0.161	-0.110
Australia	-0.023	-0.021	-0.018	-0.014	-0.011	-0.007
United Sates	-0.005	-0.004	-0.004	-0.003	-0.002	-0.001
Japan	0.004	0.003	0.003	0.002	0.001	0.001
South East Asia	0.008	0.007	0.005	0.003	0.000	-0.002
South Africa	-0.016	-0.014	-0.012	-0.010	-0.007	-0.005
Rest of South African CU	-0.069	-0.069	-0.069	-0.069	-0.070	-0.071
Madagascar	-0.119	-0.113	-0.107	-0.099	-0.091	-0.082
Malawi	-0.279	-0.272	-0.265	-0.258	-0.250	-0.243
Rest of Sub-Saharan Africa	-0.044	-0.046	-0.048	-0.050	-0.052	-0.054
United Kingdom	-0.125	-0.197	-0.269	-0.342	-0.415	-0.488
France	-0.066	-0.141	-0.216	-0.290	-0.365	-0.439
Germany	-0.079	-0.160	-0.241	-0.322	-0.402	-0.483
Rest of EU	0.011	-0.002	-0.015	-0.028	-0.041	-0.054
Rest of World	-0.004	-0.005	-0.006	-0.007	-0.008	-0.009

Source: Authors' simulations as described in the text.

Table 10: Equivalent variation as a fraction of GDP for alternative values of ρ when there are food miles changes in all active nations, % (α = 0)

	ρ				
	0.3	**0.7**	**1**	**1.3**	**1.6**
New Zealand	-0.257	-0.287	-0.299	-0.305	-0.308
Australia	-0.020	-0.023	-0.023	-0.023	-0.023
United Sates	-0.004	-0.005	-0.005	-0.005	-0.005
Japan	0.003	0.003	0.004	0.004	0.003
South East Asia	0.005	0.007	0.008	0.009	0.010
South Africa	-0.022	-0.020	-0.016	-0.010	-0.006
Rest of South African CU	-0.088	-0.081	-0.069	-0.056	-0.044
Madagascar	-0.141	-0.135	-0.119	-0.102	-0.086
Malawi	-0.361	-0.332	-0.279	-0.226	-0.179
Rest of Sub-Saharan Africa	-0.067	-0.056	-0.044	-0.034	-0.025
United Kingdom	-0.257	-0.174	-0.125	-0.094	-0.074
France	-0.182	-0.105	-0.066	-0.045	-0.032
Germany	-0.208	-0.122	-0.079	-0.054	-0.039
Rest of EU	-0.003	0.008	0.011	0.010	0.009
Rest of World	-0.009	-0.007	-0.004	-0.003	-0.001

Source: Authors' simulations as described in the text.