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Abstract

This paper introduces a model of limited consumer attention into an otherwise standard new trade theory model with love-of-variety preferences and heterogeneous firms. In this setting, we show that trade liberalization needs not be welfare enhancing if the consumers' capacity to gather and process information is limited. Rather, it intensifies competition for scarce consumer attention, thereby triggering wasteful advertising, and it may divert purchases to imported goods at an inefficient scale. Wasteful advertising provides scope for policy intervention in the form of an advertising tax. However, the tax instrument cannot eliminate inefficient diversion of consumer purchases to imports. Therefore, even under an optimal advertising tax, neither a fall in transport costs nor advancements in the global distribution of information need generate gains from trade in this framework.

JEL-Code: D110, F120, F150, L100, M370.

Keywords: new trade theory, heterogeneous firms, gains from trade, love-of-variety preferences, limited attention, advertising.

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1 Introduction

Since Krugman's path-breaking work more than three decades ago (Krugman, 1979, 1980), the idea that access to a greater mass of foreign varieties is the main engine for trade between industrialized countries and at the same time an important source for consumer welfare features prominently in the literature. Being initially seen as a simple shortcut for a preference-based channel through which gains from trade can materialize, the love-of-variety effect in the Krugman model has meanwhile become a doctrine of modern trade theory, which seems to be well in line with the data. For instance, Broda and Weinstein (2004, 2006) show that foreign varieties have contributed significantly to observed welfare gains in the US and other open economies over the last three decades of the 20th century.

But should we really believe that availability of more varieties *per se* renders consumers better off? There is strong evidence that the magnitude of available consumer goods is far beyond the mass of varieties that is perceived by individual agents, and this is not due to the lack of producer efforts to inform consumers. Rather, their advertising, which aims at bringing specific products to the perception of potential buyers, renders consumer attention a scarce resource in modern societies (Simon, 1971). For instance, Love and Lattimore (2009, p. 155) point out that "the average consumer in an OECD country is exposed to 3000 ads a day and will ignore most of them".[1] From this we can conclude that, if the consumers' capacity to gather and process information about products is limited, access to new imported varieties needs no longer provide a welfare stimulus but instead may generate losses due to over-investment into combative advertising.[2]

It is the aim of this paper to shed light on the role of limitations in consumer attention in an international trade context. For this purpose, we enrich an otherwise standard trade framework with a simple, analytically tractable model of limited consumer attention that has been proposed by Falkinger (2008a). In this model, firms have to send a sufficiently

[1] This figure might seem to be unrealistically high at a first glance, but it is well in line with other estimates on the number of advertisements an average consumer is exposed to per day. These estimates vary between 250 and 5000 (see Anderson and de Palma, 2009).

[2] Camerer (2003) lists limited consumer attention among the key challenges for future behavioral economic research, and recent years have indeed seen a surge in research dealing with this problem. Examples include Sims (2003), Gabaix, Laibson, Moloche, and Weinberg (2006), Reis (2006a,b), Falkinger (2007, 2008a), or Anderson and de Palma (2009, 2012). However, despite its prominent role in many fields of the economics discipline, limited consumer attention has so far not been at the research agenda of trade economists.

strong signal relative to their competitors in order to bring their product to the attention of consumers. Sending the signal can be interpreted as an advertising investment.[3] We model this investment as a fixed cost whose size depends on market conditions, i.e. on the mass of available consumer goods. For the trade part, we use a new trade theory model, in which consumers have love-of-variety preferences. Instead of relying on a textbook Krugman (1980) model, we choose a more elaborated framework with heterogenous firms along the lines of Melitz (2003). This allows us to distinguish between gains from trade that materialize due to access to new varieties and selection effects that impact the distribution of active firms and thus the composition of consumer goods.[4]

There are two possible regimes. In the first one, the mass of available consumer goods is small so that the total volume of information on products lies within the consumers' capacity to gather and process information. In this case, all products advertised with a minimum level of strength are perceived by consumers and the model coincides with a standard Melitz framework. We call this scenario the information-unsaturated (IU) regime. In the second regime, the consumers' perceptual capacity is subject to congestion and, in their endeavor to reach consumer attention, firms mutually overbid their advertising expenditures until firm exit has brought the mass of available products in accordance with the perception constraint of consumers. We refer to this scenario as the information-saturated (IS) regime.

We use this framework to study the welfare implications of trade liberalization, which is modeled as a reduction in iceberg transport costs between two symmetric countries.

[3]The literature distinguishes three views of advertising; the first one emphasizes the persuasive character of advertising, which influences consumer preferences, increases brand loyalty, and reduces demand elasticity with detrimental effects on efficiency; the second view points to the informative role of advertising and thus emphasizes its efficiency-enhancing effect; the third view states that advertising is complementary to a product and thus raises utility of consuming it (see Bagwell, 2007, for a literature review). In our model, advertising is informative as it brings products to the consumers' attention. At the same time, it plays a combative role as it aims at diverting consumers' attention from competitors to the own output, which may be socially wasteful (Marshall, 1919). However, advertising does not change consumer tastes (as, for instance, in Dixit and Norman, 1978), so that we can use the standard toolkit of welfare comparison to measure the efficiency effects of advertisement.

[4]In an extension to our analysis in Section 6, we investigate in detail to what extent the selection effects in the presence of heterogeneous producers are important for our results. There, we also discuss a model variant in which consumers are exposed to 'junk', which we associate with advertisement of products that are useless from the perspective of a certain consumer. In this model variant, consumers do not purchase all products which they are made aware of by advertisements.

Thereby, the IU-regime serves as a benchmark of our analysis as it reproduces the standard result of gains from trade in the Melitz framework: a larger mass of consumed product varieties and a positive compositional effect triggered by exit of the least productive firms and entry of the most productive ones in the export market. Things are different in an IS-regime. If consumer attention is limited, the love-of-variety gains from imports cannot be fully exploited. Moreover, access to additional foreign varieties after the fall in transport costs raises advertising expenditures at the firm level, which is wasteful.[5] Of course, this needs not necessarily be detrimental for welfare, as import competition and more intensive advertising induce exit of the least productive producers and thus gives way for newly imported varieties in consumer perception that are produced with higher labor productivity than the displaced domestic ones. This generates a selection effect which impacts the composition of consumer goods in a similar way as the selection effect in an IU-regime. However, with the mass of perceived and consumed varieties being limited by the consumers' capacity to gather and process information, the compositional effect is amplified and diverts consumption to imports relative to an IU-regime. If transport costs are significant, the inefficient level of imports and the waste of advertising resources can generate welfare losses from economic integration in an IS-regime.[6]

The fact that in an IS-regime trade triggers wasteful advertising plus inefficient diversion of consumer purchases to imports provides an important source for potential welfare losses. This leaves scope for policy intervention in our setting. To shed light on whether a policy that targets the problem of wasteful advertising can secure gains from trade, we investigate advertising taxation. Being interested in the principle possibility to render trade liberalization a success also in an IS-regime, we abstract from any imperfections that may

[5]The link between iceberg transport costs and advertising expenditure in an information-saturated environment relates our model to Arkolakis (2010), who considers a heterogeneous firms model of trade, in which marketing expenditures determine a firm's penetration of a market (i.e. the share of consumers, this firm can reach with its output). However, aside from the link between transport costs and advertising expenditure, the two models differ significantly in both their focus and their modeling strategy. In particular, Arkolakis does neither consider limited consumer attention, nor does he look at the role of firm-level adjustments in advertising spending for the welfare implications of trade.

[6]Egger and Kreickemeier (2009) distinguish two supply-side welfare effects that arise from importing. On the one hand, there is a negative *lost-in-transit* effect caused by goods melting away when being shipped to a foreign country and, on the other hand, there is a positive *export-selection* effect since it is the most productive foreign firms who export, so that in a symmetric world the average imported good is produced with a better technology than the average domestic product. If transport costs are high, the former effect dominates and importing is associated with a waste of resources.

arise due to unilateral tax setting in a non-cooperative policy game and focus on coordinated (symmetric) forms of policy intervention. Furthermore, in line with GATT rules we only consider non-discriminatory taxation that treats domestic and foreign firms identically. In this case, an optimal tax on advertising expenditure can indeed eliminate the problem of wasteful advertising. However, it is of no help for relaxing the consumers' perception constraint in an IS-regime and therefore cannot eliminate the inefficient diversion of consumption towards imported goods. Thus, the optimal tax does not necessarily guarantee that consumers are better off after trade liberalization. Put differently, since scarcity of attention limits the love-of-variety gains in an IS-regime, trade liberalization may reduce welfare, even if taxation eliminates excessive social costs of combative advertising.

In a final step of our analysis we investigate advancements in information and communication technologies (ICT) that reduce the costs of advertising. We conduct two comparative-static exercises. In the first one, we consider a general improvement in ICT that lowers domestic and foreign advertising costs symmetrically. In the second one, we consider an advancement in ICT that extends the range of advertising and thus reduces the extra costs of reaching foreign consumers with a given domestic investment into advertising. In this case, the ICT advancement is export biased. We show that both types of technology improvement are efficiency-enhancing and thus welfare-improving in an IU-regime. Things are different in an IS-regime. If the consumers' capacity to gather and process information is limited, a general advancement in ICT raises advertising expenditures and thus aggravates the problem of wasteful advertising. This eats up the cost reduction per unit of advertising investment, so that welfare remains unaffected by the technology improvement. The outcome is even less encouraging in the case of an export-biased advancement in ICT, as a relative decline in the fixed costs of exporting reinforces the problem of consumer purchases being diverted to imports with negative welfare consequences.

The possibility that a decline in the costs of serving foreign consumers – either due to a fall in iceberg trade impediments or due to export-biased ICT advancements – does not generate welfare gains points to an important difference between the limited attention model in this paper and other models of the new trade theory. As prominently shown in Arkolakis, Costinot, and Rodríguez-Clare (2012), textbook models of the new trade theory, such as the Armington model, Krugman (1980), Eaton and Kortum (2002), and Melitz (2003), share a remarkable property: The welfare effects are fully characterized by just two variables, namely the share of expenditures spent on domestic goods and the

elasticity of imports with respect to variable trade costs. Due to this property, an external shock that reduces the costs of serving foreign consumers induces an increase in the share of expenditures used for imports and thereby raises welfare. This is not the case in our model, where the perception constraint and competition for consumer attention uncouple welfare implications from changes in the share of expenditure on imports, so that a fall in the costs of serving foreign consumers, while always increasing import penetration, may induce welfare losses.[7]

The paper is organized as follows. Section 2 briefly summarizes the main ingredients of the Melitz (2003) model. Section 3 introduces limited attention and characterizes the trade equilibrium in the IU-regime and the IS-regime. Also, the impact of a reduction in the iceberg transport cost parameter on welfare is analyzed in this section. In Section 4, we study the role of taxation of advertising. Section 5 deals with advancements in the information and communication technology. Section 6 discusses to what extent the assumption of heterogeneous producers is relevant for our results and shows how the model can be modified to account for 'junk' as an important source of attention distraction. Section 7 concludes with a summary of the most important results and provides a discussion to what extent the insights from our model can be useful for guiding future empirical research.

2 A model of trade and heterogeneous firms

We conduct our analysis in a Melitz (2003)-type framework in which consumers have Dixit and Stiglitz (1977) love-of-variety preferences for horizontally differentiated goods. Maximization of $U = \left[\int_{\omega\in\Omega} x(\omega)^{(\sigma-1)/\sigma} d\omega\right]^{\sigma/(\sigma-1)}$ – subject to a binding budget constraint – gives an isoelastic demand function for each variety ω:

$$x(\omega) = \frac{I}{P}\left(\frac{p(\omega)}{P}\right)^{-\sigma}, \tag{1}$$

[7] The finding that trade may lower welfare in a setting with market distortions is not new (see Markusen, 1981; Newbery and Stiglitz, 1984, for two prominent early examples). The intuition for such findings is clear. If there is a distortion in autarky and this distortion is increased by trade, the resulting welfare losses may outweigh the benefits from market integration (see Shy, 1988). What is new in our model relative to this literature are the two sources of welfare losses (wasteful advertising and inefficient diversion of consumer purchases to imports) as well as the insight that constraints in the consumers' capacity to gather and process information are sufficient to change key insights from the new trade theory in a qualitative way.

where $\sigma > 1$ denotes the constant elasticity of substitution between the different varieties in consumers' utility, which equals the price elasticity of demand in this model. I is aggregate income, $p(\omega)$ is the consumer price for variety ω, and P is a true cost-of-living price index: $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega\right]^{1/(1-\sigma)}$, with Ω being the set of differentiated consumer goods.

The economy is populated by L workers, each supplying one unit of labor in a perfectly competitive market. Labor is the only factor of production and serves as a numéraire in the subsequent analysis, implying that the wage rate is normalized to one. Labor input in each firm is an affine linear function of output q: $l = f_t + q/\phi$, where ϕ is firm-specific labor productivity and f_t denotes the fixed labor requirement for overhead services, with $f_t = f$ if a firm is only active domestically and $f_t = f + f_x$ if a firm additionally exports. Each active firm produces a single variety and is a monopolist in the market for this variety. Facing demand (1), firms maximize their profits by charging a constant markup, $\sigma/(\sigma - 1)$, over their marginal costs, which are $1/\phi$ in the home market and τ/ϕ in the foreign market, with $\tau > 1$ capturing iceberg transport costs.[8]

The mass of available varieties depends on firm entry, which is modeled as in Melitz (2003). In particular, we consider an unbounded pool of potential entrants who decide upon an initial investment f_e (in units of labor). This investment provides access to a productivity lottery, in which firms draw their ϕ-level from the common distribution $G(\phi) = 1 - \phi^{-k}$, with $k > \sigma - 1$.[9] Each firm has only one draw and f_e is immediately sunk. After the lottery, firms decide upon production. If they start production, they make domestic profits $\pi(\phi) = r(\phi)/\sigma - f$ in each period in which they are active, with $r(\phi)$ denoting revenues from local sales that are an increasing function of ϕ.[10] In addition, firms

[8] A firm's cost of serving foreign consumers with one unit of its output are τ-times higher than serving domestic consumers with one unit of its output.

[9] Assuming that the productivity distribution is Pareto has evolved as industry standard in the literature on heterogeneous firms. This assumption is attractive from the perspective of analytical tractability and has considerable empirical support (Axtell, 2001; Del Gatto, Mion, and Ottaviano, 2006). Condition $k > \sigma - 1$ is needed to ensure an interior equilibrium with finite values of all endogenous variables (see Baldwin, 2005).

[10] In view of (1) and constant markup pricing, we have

$$r(\phi) = p(\phi)x(\phi) = \frac{I}{P^{1-\sigma}} \left(\frac{1}{\phi} \frac{\sigma}{\sigma - 1}\right)^{1-\sigma}.$$

Furthermore, with a constant share $(\sigma - 1)/\sigma$ of revenues used for financing variable labor input, operating profits are given by $r(\phi)/\sigma$.

can export to a *symmetric* trading partner, which generates profits $\pi_x(\phi) = \tau^{1-\sigma} r(\phi)/\sigma - f_x$. With profits depending positively on a firm's productivity, we can characterize a productivity cutoff that separates active from inactive producers. This productivity cutoff, ϕ^*, is determined by the *zero cutoff profit condition* $\pi_t(\phi^*) = 0$, where $\pi_t(\phi)$ denotes total (domestic plus foreign) per-period profits of a firm with productivity ϕ.

Firms have an infinite horizon and face an exogenous destruction probability which forces a share δ of producers to exit in each time period. Then, abstracting from time discounting and focusing on steady state equilibria, new firms will enter the productivity lottery in each period until the expected present value of profits, $\bar{\pi}_t/\delta$, multiplied by the probability of a successful draw, $1 - G(\phi^*)$, equals the lottery participation cost, f_e. This gives the *free entry condition*

$$\bar{\pi}_t = \frac{\delta f_e}{(\phi^*)^{-k}}, \tag{2}$$

which establishes a relationship between average (per-period) profits $\bar{\pi}_t$ and cutoff productivity ϕ^*.

The zero-cutoff profit condition provides a further link between average profits and the cutoff productivity, with the specific form of this link depending on how many firms self-select into export status. Provided that the beachhead costs for entering the foreign market are sufficiently high relative to domestic ones, i.e. $f_x/f > \tau^{1-\sigma}$, the model leads to partitioning of firms by their export status, with only the most productive firms serving both domestic and foreign consumers. In this case, the productivity of the marginal exporter, ϕ_x^*, is larger than the productivity cutoff in the domestic market, ϕ^*, and the proportion of firms that export is given by $\chi \equiv (\phi_x^*/\phi^*)^{-k} = [(f_x/f)\tau^{\sigma-1}]^{-k/(\sigma-1)} < 1$.[11] This is the parameter domain, we are focusing on in the subsequent analysis. Adding up profits over all active producers and taking into account that firms differ in their export status, we get for average (per-period) profits in the open economy (see the appendix):

$$\bar{\pi}_t = \left(1 + \chi \frac{f_x}{f}\right) \frac{(\sigma - 1)f}{k - \sigma + 1}. \tag{3}$$

The latter equation is based on producers with $\phi \geq \phi^*$ and thus directly related to $\pi_t(\phi^*) = 0$. Hence, it represents a *modified* zero-cutoff profit condition.

[11] Whereas the marginal producer is characterized by $r(\phi^*)/\sigma = f$, the marginal exporter is characterized by $\tau^{1-\sigma} r(\phi_x^*)/\sigma = f_x$. Hence, $\phi_x^* > \phi^*$ and thus $\chi < 1$, if $f_x/f > \tau^{1-\sigma}$. On the contrary, if $f_x/f \leq \tau^{1-\sigma}$, then $\phi_x^* = \phi^*$ and $\chi = 1$, such that all firms export.

Together, Eqs. (2) and (3) determine the productivity cutoff, ϕ^*, and average profits, $\bar{\pi}_t$. Furthermore, aggregate labor demand[12] must equal total labor supply, i.e. $\sigma M(\bar{\pi}_t + f + \chi f_x) = L$, where M denotes the mass of producers in a country. Using this and Eq. (3) in $M_t = M(1+\chi)$, we can solve for M_t, which is the total mass of (domestic and foreign) varieties that are available in the market. We have:

$$M_t = \frac{1+\chi}{1+\chi f_x/f} \frac{L(k-\sigma+1)}{f\sigma k}. \tag{4}$$

In a model in which consumers have love-of-variety preferences, the mass of available consumer goods is a key determinant of a consumer's welfare, U, which in our framework equals the real wage, w/P, and, as formally shown in the appendix, is given by

$$U = \frac{\sigma-1}{\sigma} \left[\frac{L}{\sigma f}\right]^{\frac{1}{\sigma-1}} \left[\left(1+\chi\frac{f_x}{f}\right) \frac{(\sigma-1)f}{(k-\sigma+1)\delta f_e}\right]^{\frac{1}{k}}. \tag{5}$$

This completes the characterization of the trade equilibrium.

3 Limited attention in an open economy

We now extend the basic trade model of Section 2 to one with limited consumer attention. Following Falkinger (2008a), we use a key insight from psychological research on human information processing as the cornerstone of our attention model: "[C]apacity limits *and* perceptual gating both characterize human perceptual processing" (Pashler, 1998, p. 224). This implies a fundamental bottleneck for a firm that tries to reach consumer attention. One may think about this bottleneck in terms of Kahneman's (1973) dual-task approach. Individuals have a certain amount of perceptual capacity and the way in which a specific signal from advertising is processed by a consumer depends on the capacity left by the other signals to which the consumer is exposed. If no capacity is left the signal is ignored. The perceptual gate determines which signals are processed with priority. It is assumed that the strongest signals come first. As a result, two regimes are possible: As long as total

[12] In view of constant markup pricing, a share $(\sigma-1)/\sigma$ of total revenues, R, is spent for variable labor input in production, while a share $1/\sigma$ remains for fixed total per-period labor input in overhead services, $M(f+\chi f_x)$, and aggregate profits $M\bar{\pi}_t$. Hence, $R = \sigma M[\bar{\pi}_t + f + \chi f_x]$ and, because of $w = 1$, variable labor input in production is given by $(\sigma-1)M[\bar{\pi}_t + f + \chi f_x]$. Since each period δM firms must be replaced to keep M at the steady state level, we have in addition $\delta M f_e/(1-G(\phi^*))$ units of labor required by new entrants for participating in the productivity lottery. Adding up the three components of labor demand and using (2), we obtain for the aggregated labor demand $\sigma M[\bar{\pi}_t + f + \chi f_x]$.

signal exposure lies below the consumer's capacity constraint, there is no competition for scarce perceptual resources and thus no interference between different signals. If however the mass of signals to which a consumer is exposed exceeds the perceptual capacity, signals whose strength lies below a certain threshold are crowded out.

As in Falkinger (2008a), we account for the consumers' perceptual constraint by assuming that, irrespective of the mass of actually supplied and advertised varieties, consumers cannot process information of more than $\bar{M}$ goods, and hence purchase $M_t \leq \bar{M}$ varieties in equilibrium.[13] Firms, on the other hand, while taking the capacity constraint as given, can invest into advertising in order to bring their products to consumers' attention.[14] Thereby, firms must advertise with a sufficient strength in order to pass the perceptual gate of consumers. The minimum strength of advertising that makes a product visible to consumers is identical for all firms and denoted by $\rho_{min} \geq 1$. Even without competition for attention a minimum level of advertising, normalized to $\rho_{min} = 1$, is required to make consumers aware of a product and its characteristics. If attention is scarce, competition for attention drives up the minimum strength of advertising. There are no other benefits of advertising for firms in our model than passing the perceptual gate of consumers, and thus firms advertise at a strength of $\rho = \rho_{min}$ in equilibrium.[15] The equilibrium value of ρ_{min} (and thus ρ) depends on the scarcity of attention and is endogenously determined.

Limited consumer attention renders advertising an important fixed cost factor. A tractable specification that integrates this into our trade model is

$$f = a\rho^{\alpha}, \qquad f_x = a_x\rho^{\alpha}, \qquad \alpha > 0. \tag{6}$$

Thereby, focusing on a parameter domain with $a \geq a_x$ is meaningful in our context.

[13] The assumption of a definite upper bound for the number of perceived products is clearly a drastic simplification. In reality, $\bar{M}$ may respond to stimulus exposure. But this would not change the main conclusions of this paper qualitatively. The essential point is that scarcity of attention diminishes the love-of-variety gains from additional imports and triggers competition for attention with negative externalities.

[14] Advertising provides accurate information about the relevant product characteristics. Unlike advertising models based on the pioneering work of Ozga (1960) and Butters (1977), and, in particular, in contrast to Arkolakis (2010), the advertised information is a public good, which is equally available for all consumers in a certain country, if they pay attention to it.

[15] This assumption simplifies our model enormously and helps us focusing on the role of limited consumer attention – instead of changes in consumer behavior in response to marketing. The assumption is akin to Bagwell's (2007) conclusion from reviewing the advertising literature that "advertising often entails diminishing returns beyond a threshold level, where the threshold level varies across circumstances and may be small" (p. 1734).

For instance, the borderline case of $a_x = 0$ can be associated with an information and communication technology (ICT) that provides world-wide dissemination of information, such that firms do not have to bear additional costs of bringing their product to the attention of foreign consumers. In this case, the beachhead costs of entering the foreign market are zero, implying that all firms engage in exporting, and hence there is no selection of just the best firms into export status. In the other limiting case of $a_x = a$, the range of ICT is confined to the local market and firms have to promote their products separately in the two economies. In the intermediate case of $a_x \in (0, a)$, on which we focus in the subsequent analysis, part of the advertising investment, as for instance the set up of a principle advertising strategy, has a global character, while the other part is location-specific, for instance due to different languages in the two countries. With specification (6), the assumption $f_x/f > \tau^{1-\sigma}$, which implies $\phi_x^* > \phi^*$, reduces to $a_x/a > \tau^{1-\sigma}$. Therefore, we focus on $a_x/a \in (\tau^{1-\sigma}, 1)$ in the subsequent analysis. Finally, by suppressing country indices of ρ, we acknowledge the symmetry of countries, which implies that exporters face the same mass of competitors at home and abroad, and hence must advertise with the same strength in their domestic and their foreign market.

In order to shed light on the role of limited attention in interaction with trade, we substitute (6) into Eq. (4). This gives us

$$M_t = \frac{1+\chi}{1+\chi a_x/a} \frac{L(k-\sigma+1)}{a\rho^\alpha \sigma k} \equiv RHS(\rho), \tag{4'}$$

with $dRHS/d\rho = -RHS\alpha/\rho < 0$. There are two possible scenarios. The first scenario is one, in which the capacity of consumers to process information is not exhausted and firms need not compete for consumer attention. In this case, we have $M_t < \bar{M}$ and $\rho = 1$. This is the *information-unsaturated* (IU) regime. The second scenario is one, in which the consumer's constraint to process information is binding, implying that $M_t = \bar{M}$ and $\rho \geq 1$.[16] We use the term *information-saturated* (IS) regime to refer to this scenario.

[16] In principle, it would be possible that at a given strength ρ more than $\bar{M}$ firms are sending signals to consumers. In this case the probability of being perceived by a consumer, and thus the consumer coverage of a firm, would be $\bar{M}/M_t < 1$. This however is not consistent with an equilibrium, as firms could increase their market size significantly by just marginally increasing the advertising expenditure, and they would do so when maximizing profits. Furthermore, similar to Melitz (2003) the equilibrium generates a ranking such that only the most productive firms start production. Less productive firms stay out of the market as increasing their advertising expenditures to a level which makes them visible for consumers would induce negative profits.

Figure 1 depicts the two scenarios graphically. For RHS, the economy is in an IU-regime with the equilibrium represented by point A. All firms that find it profitable to enter and start production with advertising strength $\rho = 1$ are perceived by the consumers. As a consequence, no firm has an incentive to raise its advertising strength above $\rho = 1$, because this would just increase fixed costs without a positive effect on the firm's operating profit. In contrast, for RHS', the economy is in an IS-regime with equilibrium point A', in which attention is scarce. In this case, at $\rho = 1$ more than $\bar{M}$ firms would find it profitable to enter the market and start production. As a consequence, firms raise their strength of advertising above $\rho = 1$ in order to attract consumers' attention. Mutual overbidding of advertising effort drives up fixed costs and establishes an equilibrium at A'.

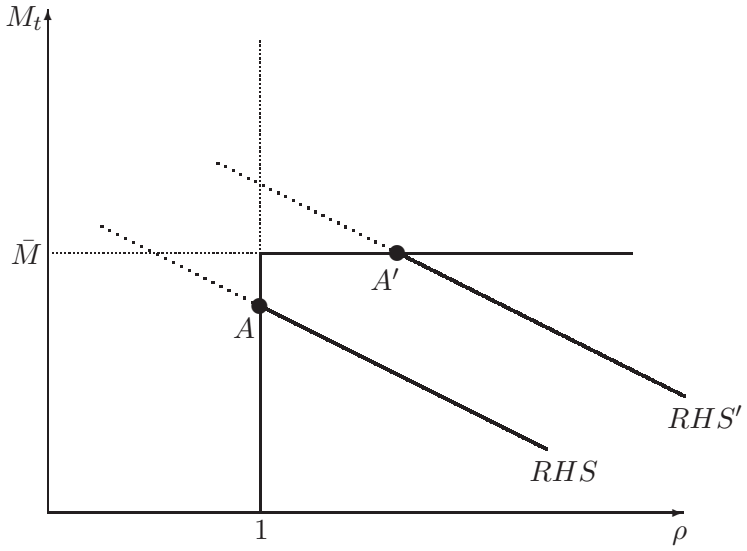

Figure 1: Advertising in an IU- and in an IS regime

A change in transport costs has now two effects. On the one hand, from inspection of $(4')$ it is obvious that the position of the relevant RHS-locus depends on the share χ of exporting firms, which in turn is given by $\chi = (a_x/a)^{-k/(\sigma-1)}\tau^{-k}$. Hence, the size of iceberg transport cost parameter τ is a key determinant for the equilibrium information regime. On the other hand, the impact of a change in the transport cost parameter τ on consumer welfare U depends on the information regime which prevails in equilibrium. The next two subsections discuss these effects in more detail. We start with a comparative-

static analysis of transport cost changes in an IU-regime in Subsection 3.1 and discuss the IS-regime in Subsection 3.2.

3.1 Falling transport costs in an IU-regime

If there is no scarcity of attention, i.e. if $M_t < \bar{M}$, a marginal reduction in the iceberg transport cost parameter exerts similar effects as in the original Melitz (2003) paper. In particular, differentiating (4′) and (5), evaluated at $\rho = 1$, with respect to τ yields

$$\frac{dM_t}{d\tau} = \frac{(1 - a_x/a)M_t}{(1+\chi)(1+\chi a_x/a)} \frac{d\chi}{d\tau} < 0, \tag{7}$$

$$\frac{dU}{d\tau} = \frac{(a_x/a)U}{k(1+\chi a_x/a)} \frac{d\chi}{d\tau} < 0, \tag{8}$$

respectively. For a given mass of competitors in either market, M, a transport cost reduction triggers an expansion of exports at both the intensive margin (higher foreign sales of initial exporters who stay in the market) and, provided that $\chi < 1$, the extensive margin (self-selection of new firms into export status). This generates additional demand for labor and compels the least productive non-exporters to leave the market. Therefore, the productivity cutoff increases, which generates welfare gains. At the same time, there are two counteracting effects on the mass of product varieties that are available for consumers. Access to newly exported foreign goods raises M_t, while exit of the least productive local producers lowers it. With $a > a_x$, it is the first effect that dominates, so that a fall in per unit transport costs raises the mass of available product varieties (see Eq. (7)). Total transport costs may rise or fall. On the one side, more goods are imported; on the other side, each unit can be transported at a lower cost. Note also that the rise in marginal productivity implies a lower success rate for market entrants, which is $(\phi^*)^{-k}$. In sum, however, the gains from higher productivity and more consumed varieties dominate so that we have the welfare gain shown by Eq. (8).

While these effects are well-known from existing work on heterogeneous firms in open economies, it is a novel feature of our analysis that a fall in the transport cost parameter brings the open economy closer to the IS-regime, which we analyze in detail in the next subsection.

3.2 Falling transport costs in an IS-regime

If the capacity of consumers to gather and process information is exhausted, the mass of perceived varieties is fixed by $\bar{M}$ and the strength of advertising is determined by Eq. (4′), when accounting for $M_t = \bar{M}$. Applying the implicit function theorem, we obtain

$$\left.\frac{d\rho}{d\tau}\right|_{M_t=\bar{M}} = \frac{\rho(1-a_x/a)}{\alpha(1+\chi)(1+\chi a_x/a)}\frac{d\chi}{d\tau} < 0. \tag{9}$$

A decline in the transport cost parameter renders exporting more attractive and the share of exporters, $\chi = (a_x/a)^{-k/(\sigma-1)}\tau^{-k}$, rises. In an IU regime, the expansion of exports at the extensive margin, would raise the mass of available varieties in either economy *ceteris paribus*. However, with a binding perception constraint, there is no market for additional varieties, because consumers do not pay attention to them. Hence, in order to attract consumers' attention firms raise their advertising strength, ρ, which induces higher fixed costs in both the domestic and the foreign market. The higher fixed costs reinforce firm exit at the bottom of the productivity distribution, implying that M falls stronger and ϕ^* rises by more than in an IU-regime. A new equilibrium is reached if sufficiently many non-exporters have left the market, such that the remaining firm population is consistent with the constraint $M_t = (1+\chi)M = \bar{M}$, where the declining unit costs of transport have increased the share of exporters, χ. In the new equilibrium, all firms again advertise with the same strength, which, however, is higher than it was prior to the fall in transport costs. This can easily be seen by means of Figure 1, in which a decline in τ corresponds to an upward shift of RHS'.

While in an IS-regime a fall in transport costs raises firm-level advertising expenditures, with a negative externality on competitors, this does not automatically mean that economy-wide advertising expenditures increase as well. The reason is that the least productive firms exit the market and stop advertising at all. Noting that total advertising expenditures are given by $M_t a\rho^{\alpha}(1+\chi a_x/a)/(1+\chi)$ and accounting for (4′), we find that the two opposing effects exactly cancel out, so that total advertising expenditures remain unaffected by a fall in the iceberg transport cost parameter. Still, the increase in firm-level advertising is a waste of resources. Without competing for attention by raising advertising strength beyond the minimum level $\rho = 1$, total advertising expenditures would be $\bar{M}a(1+\chi a_x/a)/(1+\chi)$ in the IS-regime, which is declining in τ. Since $a_x < a$, the global distribution of information to consumers is less expensive than advertising the consumers of each country separately. International trade allows to exploit this scale ef-

fects in ICT. In an IU-Regime, the effect is used to disseminate information about a larger variety of products so that total advertising expenditure remain constant at the level $M_t a(1+\chi a_x/a)/(1+\chi) = L(k-\sigma+1)/(k\sigma)$. In contrast, in an IS-regime with competition for attention total advertising expenditures are kept at this level by increasing advertising costs per product rather than increasing the variety of products. Formally, the resources lost by wasteful advertising are given by the difference

$$\frac{L(k-\sigma+1)}{k\sigma} - \bar{M}a\frac{1+\chi a_x/a}{1+\chi}. \tag{10}$$

This waste increases with a fall in the unit costs of transport, since international trade stimulates the competition for attention in an IS-regime.

Of course, the wasteful competition for attention is not the only distortion induced by the perception constraint in our setting. Regardless of the level of advertising effort, i.e. even at $\rho = 1$, in the IS-regime one important channel for gains from trade is closed, namely the love-of-variety effect. Therefore, lower unit costs of transport, while always being beneficial in the IU-regime, may well fail to generate gains in the IS-regime, even without wasteful advertising. It is true that the shift of demand from local firms to imports generates productivity gains. But with the gain from a larger variety missing, this may not be sufficient to outweigh possible negative effects, in particular the transport costs induced by the additional import. The interaction between limited attention and falling unit costs of trade leads in this case to an inefficient diversion of both consumer attention and consumer expenditures to imports. In other words, importing is excessive in this case.

In sum, compared with the IU-regime, in an IS-regime two distortions change the trade-offs between the benefits and the costs of trade – wasteful advertising and inefficient diversion of consumers' attention and expenditures to imports.[17] As a result, welfare gains from trade are not guaranteed under limited attention.

For a detailed analysis of the welfare effects, we substitute (6) into (5) and differentiate the resulting expression with respect to τ. Accounting for (9), we have

$$\left.\frac{dU}{d\tau}\right|_{M_t=\bar{M}} = \frac{U}{(1+\chi)k}\left[1 - \frac{(1-a_x/a)k}{(1+\chi a_x/a)(\sigma-1)}\right]\frac{d\chi}{d\tau}, \tag{11}$$

[17] It is worth to notice that the two distortions are not an artifact following from our simple modeling of the perception constraint, with a definite limit on the perceptual capacity. They emerge quite generally if perception of additional varieties deteriorates when the supply of varieties reaches a certain level. The deterioration of perception will trigger competition for attention and depress the love-of-variety gains from trade.

with derivation details being deferred to the appendix. We see that the welfare implications of trade liberalization crucially depend on the interaction between τ and a_x/a, which reflects the range of ICT. Figure 2 illustrates this. We assumed $a_x/a > \tau^{1-\sigma}$ – otherwise all firms would export, and $a_x/a < 1$ – otherwise trade would not increase the mass of consumed varieties in an IU-regime. So $a_x/a \in (\tau^{1-\sigma}, 1)$ is the area, we focus on in Figure 2. If a_x/a is low, domestic advertising information can easily be spread to foreign markets, that means, ICT has a (rather) global range. In this case, a fall in the transport cost parameter generates a strong incentive for initial non-exporters to start exporting, thereby providing a strong stimulus on firm-level advertising. Hence, many low-productivity firms are forced to exit, so that the distortions from wasteful advertising and diversion of consumption towards imports dominate the gains associated with a higher productivity cutoff, and welfare deteriorates if τ shrinks. To put it formally, we call ICT global if $a_x/a < (k-\sigma+1)/(k+\sigma-1)$. Then, according to (11), $dU/d\tau > 0$ under global ICT. In Figure 2, this corresponds to the area at the bottom to the right.

If a_x/a is high, the opposite holds. To be more specific, if $a_x/a > (k-\sigma+1)/k$, we speak of a (rather) local ICT range. In this case, $dU/d\tau < 0$, according to (11). In Figure 2 this corresponds to the band at the top. A given reduction in the iceberg transport cost parameter exerts a minor impact on the extensive margin of exporting (χ), and firms will respond to the fall in transport costs with just a small increase in their advertising strength. Hence, the distortions from wasteful advertising and excessive importing are small, so that gains from trade materialize through the increase in the cutoff productivity level. Finally, if ICT has an intermediate range, i.e. if $(k-\sigma+1)/k > a_x/a > (k-\sigma+1)/(k+\sigma-1)$, we can identify a critical transport cost level[18]

$$\bar{\tau} \equiv \left(\frac{a}{a_x}\right)^{\frac{1}{\sigma-1}} \left[\frac{1}{(a/a_x)\left[k/(\sigma-1)-1\right]-k/(\sigma-1)}\right]^{\frac{1}{k}}, \tag{12}$$

such that $dU/d\tau >, =, < 0$ if $\tau >, =, < \bar{\tau}$. Put differently, a decline in the iceberg transport cost parameter exerts a negative (positive) welfare effect if transport costs have been high (low) initially. See Figure 2 for an illustration.

The following proposition rounds off the formal discussion in this and the former subsection by summarizing the main insights in a non-technical way.

[18]Setting the bracket term on the right-hand side of (11) equal to zero and solving the respective expression for χ yields $\chi = (a/a_x)[k/(\sigma-1)-1] - k/(\sigma-1)$. Substitution of $\chi = [(a_x/a)\tau^{\sigma-1}]^{-k/(\sigma-1)}$, then establishes Eq. (12), with $\tau > (a/a_x)^{1/(\sigma-1)}$ being necessary for $\chi < 1$.

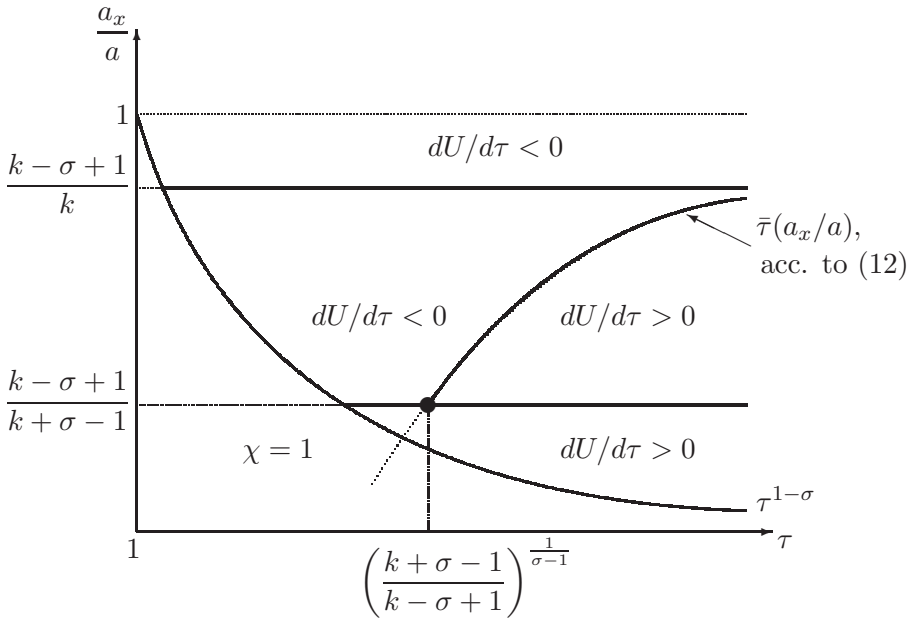

Figure 2: Welfare effects of changes in the iceberg transport cost parameter

Proposition 1. *In an information-saturated regime, a fall in iceberg transport costs may exert negative welfare effects, as firms in an endeavor to attract consumers' attention raise their advertising expenditures. Moreover, the exit of low productivity firms leads to inefficient diversion of demand to imported goods, since the love-of-variety gains from trade do not materialize under limited attention. This is in contrast to an information-unsaturated regime, in which a decline in transport costs always generates welfare gains.*

4 Trade liberalization and taxation of advertising

An immediate question arising from our analysis above is how policy intervention can be designed to establish positive welfare effects of trade liberalization in an IS-regime. Restricting our attention to non-discriminatory policy measures and noting that wasteful advertising is an important source of negative welfare effects, we consider a *uniform* advertising tax as a natural instrument for policy intervention. Furthermore, we assume that the two symmetric countries coordinate their policies and implement the same advertising tax. Focusing on coordinated policies is attractive for two reasons. On the one hand, it avoids complications arising from non-cooperative taxation in a trade model with

heterogeneous producers (see Davies and Eckel, 2010). On the other hand, coordination generates the largest potential for welfare-increasing policy effects and thus allows us to answer the question if in an IS-regime welfare gains from trade liberalization can be guaranteed under an optimistic view upon the role of governments in the process of economic integration.

For a proportional tax, with tax rate $t \geq 0$, the effective advertising costs for the firm are

$$f = (1+t)a\rho^{\alpha}, \qquad f_x = (1+t)a_x\rho^{\alpha}. \tag{13}$$

Since total advertising expenditures of firms net of tax are given by $Ma\rho^{\alpha}(1+\chi a_x/a)$, the total tax revenue amounts to $T = tMa\rho^{\alpha}(1+\chi a_x/a)$. While T is a component of the fixed production costs of firms which has to be covered by their total revenue, R, it does not require labor resources. That means, total labor demand is now given by $R-T$ rather than by R. It is assumed that the tax is redistributed to consumers via a lump-sum transfer. Thus, their total disposable income is $I = L + T$. With these assumptions at hand, we can derive from $R = I$ the following equation in an analogous way to the derivation of Eq. (4):

$$M_t = \frac{1+\chi}{1+\chi a_x/a}\frac{k-\sigma+1}{\sigma k}\frac{L+T}{a\rho^{\alpha}(1+t)}. \tag{4''}$$

Furthermore, utility is given by $U = (L+T)/(LP)$, which can be expressed as follows:

$$U = \frac{L+T}{L}\frac{\sigma-1}{\sigma}\left(\frac{L+T}{\sigma a\rho^{\alpha}(1+t)}\right)^{\frac{1}{\sigma-1}}\left[\left(1+\chi\frac{a_x}{a}\right)\frac{\sigma-1}{k-\sigma+1}\frac{a\rho^{\alpha}(1+t)}{\delta f_e}\right]^{\frac{1}{k}}, \tag{5'}$$

with the last bracket term representing the cutoff productivity, ϕ^*, as a function of the tax rate (see Eqs. (2) and (3)).

If the economy is in an IU-regime without taxation, our model features the well-known result that firm entry is efficient in the Melitz (2003) model.[19] As pointed out by Baldwin (2005), there are two counteracting externalities of firm entry. On the one hand, firms do not consider their negative impact on competitors and, on the other hand, they do not account for the extra consumer surplus of adding an additional variety to the consumption basket. These two externalities exactly offset each other in the Melitz (2003) model, and

[19] To be more specific, the outcome is "constrained" efficient, because it is assumed that the social planner takes the pricing decision of firms as given (see Jung, 2012).

hence governments that aim at maximizing utility (5′) set $t = 0$ in the IU-regime.[20]

Things are different in an IS-regime, where consumer attention is a scarce resource. In this case, decentralized firm entry is no longer efficient. Governments can improve welfare U by setting a positive tax rate $t > 0$, thereby lowering advertising strength ρ and thus reducing wasteful competition for attention. To be more specific, substituting $T = tMa\rho^{\alpha}(1 + \chi a_x/a)$ into (4″), accounting for $M = M_t(1+\chi)^{-1}$, and setting $M_t = \bar{M}$, we can explicitly solve for the strength of advertising in an IS-regime:

$$\rho = \left[\frac{1+\chi}{1+\chi a_x/a} \frac{k-\sigma+1}{k\sigma + t(k+1)(\sigma-1)} \frac{L}{a\bar{M}} \right]^{\frac{1}{\alpha}}. \tag{14}$$

Differentiating (14) with respect to t gives

$$\frac{d\rho}{dt} = -\frac{\rho}{\alpha} \frac{(k+1)(\sigma-1)}{k\sigma + t(k+1)(\sigma-1)}, \tag{15}$$

which is negative and thus confirms the claim that a higher tax lowers the strength of advertising. However, the tax-induced reduction in the strength of advertising does not compensate the direct effect of a higher tax rate on the fixed costs of domestic production, and hence firms face higher fixed costs when t increases.[21] As a consequence, taxation of advertising renders production of the least productive producers unattractive and *ceteris paribus* reduces the mass of firms. On the other hand, higher disposable income and the increased productivity of the marginal firm raise expected profits of the average firm, which makes participation in the productivity lottery more attractive. Since an IS-regime leads to an advertising strength which makes entry consistent with $M = \bar{M}(1+\chi)^{-1}$, the two effects exactly cancel out in equilibrium. Note that χ is invariant to a uniform advertising tax. Finally, setting $M_t = \bar{M}$ in (4″), solving for $L + T$ and substituting the resulting expression in (5′), we see that

$$\operatorname{sgn}\left[\left. \frac{dU}{dt} \right|_{M_t=\bar{M}} \right] = \operatorname{sgn}\left[\left. \frac{\alpha}{\rho} \frac{d\rho}{dt} \right|_{M_t=\bar{M}} + \frac{1}{1+t} \right], \tag{16}$$

[20] This is different in a setting with more than one sector. For instance, Pflüger and Südekum (2012) consider a model with a differentiated and a homogeneous goods industry. Provided that prices are equal to marginal costs in the homogeneous goods industry, whereas prices are set as a constant markup on marginal costs in the differentiated goods industry, consumers spend too little for the differentiated goods. This generates a distortion and implies that firm entry is too low in the differentiated goods industry (Benassy, 1996). As a consequence, social welfare can be improved by a subsidy on firm entry.

[21] Substituting (14) into $f = a\rho^{\alpha}(1+t)$ and differentiating the resulting expression with respect to t gives $df/dt > 0$, since $k > \sigma - 1$ holds by assumption.

which, in view of (15), is positive, since $k > \sigma - 1$ holds by assumption. Hence, in an IS-regime the considered tax instrument is a remedy for the problem of wasteful advertising, and thereby generates positive welfare effects.

Putting together our insights from the policy analysis, we conclude that the welfare-maximizing (non-negative) advertising tax is zero if an IU-regime results in the pre-tax equilibrium, and it is given by[22]

$$\hat{t} = \frac{L(k-\sigma+1) - \sigma k \bar{M} a (1+\chi a_x/a)/(1+\chi)}{(k+1)(\sigma-1)\bar{M} a (1+\chi a_x/a)/(1+\chi)} > 0, \tag{17}$$

otherwise. We can differentiate $\hat{t}$ with respect to τ in order to shed light on how governments should adjust their tax policy in an IS-regime, when transport costs decline. Straightforward calculations give $d\hat{t}/d\tau < 0$, implying that in an IS-regime governments should raise advertising taxes in response to economic integration. This points to a new channel through which gains from trade can materialize in an IS-regime: higher revenues from advertising taxation. All other things equal, the advertising tax renders positive welfare effects of a transport cost reduction more likely. However, as shown in the appendix, the optimal tax response to a given change in τ needs not be sufficient for generating positive welfare effects of economic integration, in particular if $\bar{M}$ is relatively low and τ high initially. The reason is that, while the tax is a suitable instrument for correcting the problem of wasteful advertising, it cannot relax the consumers' perception constraint, which closes one important channel through which gains from trade typically materialize in models of the new trade theory: consumption of additional varieties of the consumer good. As a consequence, limited attention may lead to excessive importing and thus waste due to goods melting away, when being shipped internationally. Since taxation of advertising does not reduce import competition, it cannot eliminate this type of waste.

The following proposition summarizes the main insights from the policy analysis.

Proposition 2. *In an information-unsaturated environment, firm entry is efficient, and hence there is no need for policy intervention in the form of an advertising tax. In an information-saturated regime, applying a non-discriminatory and internationally coordinated tax on advertising is a useful instrument to overcome the problem of wasteful advertising. The optimal tax rate increases with economic integration. However, the instrument*

[22] The optimal tax in an IS-regime is characterized by the conditions $M_t = \bar{M}$ and $\rho = 1$, and it follows from solving (14) for t. Using (4″), Eq. (17) can be rewritten as $\hat{t} = \sigma k(L\hat{t} - T)/[(k+1)(\sigma-1)(L+T)]$, which is positive, as the revenue of taxing fixed labor input in advertising, T, is smaller than taxing all labor, $\hat{t}L$.

is of no help for eliminating the inefficient diversion of consumer purchases to imports which can arise under limited attention. Hence, welfare gains from a marginal transport cost reduction are not guaranteed in an IS-regime even if governments set the advertising tax optimally.

5 Advancements in information and communication technology

In the previous two sections, we have studied the consequences of trade liberalization for optimal taxation and consumer welfare. Thereby, we have shown that the available ICT for the distribution of advertisements is a key determinant of the welfare effects of international integration under limited consumer attention. In the last two decades, ICT itself has been subject to significant changes, with the respective changes being interpreted in the literature as an important stimulus for economic growth (Jorgenson and Vu, 2005; Venturini, 2009) and international trade (Freund and Weinhold, 2004; Fink, Mattoo, and Neagu, 2005). It is therefore worthwhile to look at the impact that changes in ICT exert on welfare in our model with limited consumer attention. To shed light on this issue, we distinguish between general ICT advancements, which affect domestic and foreign costs of advertising symmetrically, and advancements that reduce in particular the extra costs of targeting foreign consumers. In our model, the former means that a and a_x decline *pari passu*, while the latter is associated with a decline in a_x for a given a.

We start with a discussion of general advancements in ICT. A proportional reduction in the fixed cost parameters a and a_x leaves the decision of firms upon exporting (χ) unaffected. However, it lowers the fixed costs of production. Hence, additional firms enter at the bottom of the productivity distribution, and cutoff productivity ϕ^* falls. In an IU-regime, the perceptual capacity of consumers is not a scarce resource, so that each additional product is perceived by the consumers at home or globally if a firm invests a or $a+a_x$, respectively, in ICT. The additional market entry at the bottom of the productivity distribution raises the amount of supplied and consumed product varieties, and firms have no reason to adjust their advertising strength in response to the technology improvement. This leads to a welfare increase, despite the fall in the cutoff productivity level. In contrast to this, consumer attention is scarce if the economy is in an IS-regime, and firms raise their advertising effort in response to the technology advancement, as competition for attention

is reinforced by additional entry attempts of firms at the bottom of the productivity distribution. With the total mass of perceived product varieties being limited by $\bar{M}$, the increase in advertising strength eats up all the benefits from the *pari passu* decline in a and a_x, implying that firm-level fixed costs, the mass of available domestic and imported varieties, and thus welfare remain unaffected by such general advancements in ICT (see the appendix for formal details).

We next turn to the analysis of biased ICT change which reduces the extra costs of targeting foreign consumers (export-biased ICT change, in short). The 'Internet revolution' in the early 1990s is a good example for such a change. It has opened a new medium for advertising, with a much more global range than its offline alternatives. Empirical evidence shows that due to its wider range of information dissemination, the internet has attracted a substantial share of total advertising expenditures since the beginning of its commercial use in 1994.[23] In our model, these changes can be captured by a decline in parameter a_x for a given level of a. This interpretation is akin to the conclusion by Freund and Weinhold (2004) that "the Internet reduces market-specific fixed costs of trade" (p. 171).

A fall in cost parameter a_x renders exporting more attractive. This induces exit of the least productive non-exporters, so that the cutoff productivity, ϕ^*, unambiguously increases when the fixed costs of exporting fall (see Melitz, 2003).[24] For the effect of a fall in a_x on the mass of available varieties, we have to distinguish between the two information regimes. In an IU-regime, there are two counteracting effects. While the increase in the proportion of exporters, χ, provides access to additional foreign varieties, there is exit of domestic producers, M. Differentiating $(4')$ at $\rho = 1$, we can show that the former effect dominates if $a_x < a$, so that the mass of varieties available to consumers increases. This together with the stimulus on the productivity cutoff leads to an increase in welfare (see Eq. (5)).

In an IS-regime, the equilibrium strength of advertising is determined by (14), with

[23] Evans (2009) presents empirical evidence that the revenue share for online advertising in total advertising has significantly increased between 2000 and 2008, from 3.2 to 8.8 percent.

[24] Like other equilibrium variables in our model, ϕ^* depends on the term $1 + \chi a_x/a$ (see (24) in the appendix). With $\chi = (a_x/a)^{-k/(\sigma-1)}\tau^{-k}$ we have $\chi a_x/a = (a_x/a)^{(\sigma-1-k)/(\sigma-1)}\tau^{-k}$, which falls if a_x declines, as $k > \sigma - 1$ holds by assumption. Note that this argument applies for both the IU- and the IS-regime, so that the $(1 + \chi a_x/a)$-term always rises if a_x declines for a given a. Moreover, the term $(1 + \chi)/(1 + \chi a_x/a)$ rises as well if a_x declines for a given a.

$t = 0$ in the absence of taxation. Differentiation with respect to a_x yields

$$\frac{d\rho}{da_x} = -\frac{\rho}{\alpha} \frac{\chi}{a_x(1+\chi a_x/a)} \left[\frac{1-a_x/a}{1+\chi} \frac{k}{\sigma-1} + \frac{a_x}{a} \right], \tag{18}$$

which, in view of $a_x < a$, is negative, so that each firm advertises at a higher intensity, ρ, when the extra costs of targeting foreign consumers' attention, a_x, shrink. Compared to the IU-regime, additional advertising at the firm level reinforces exit of low-productivity firms, thereby amplifying the positive effect on cutoff productivity ϕ^*. The now stronger selection at the bottom of the productivity distribution gives an additional welfare stimulus, which, however, is counteracted by an efficiency loss stemming from wasteful advertising and inefficient diversion of purchases towards foreign goods. The latter comes form the fact that the rising imports induce additional transport cost expenditures, on the one side, but scarcity of consumer attention does not allow to exploit the love-of-variety gains, on the other side. As shown in the appendix, the two negative distortions – wasteful advertising and diversion of purchases towards imports – dominate in our model, so that an export-biased advancement in ICT leads to a welfare loss in an IS-regime.[25]

The following proposition summarizes the main insights from our analysis in this section.

Proposition 3. *A general advancement in ICT raises welfare in an IU-regime and leaves welfare unaffected in an IS-regime. An ICT advancement that is biased towards international trade, lowers the fixed costs of exporting and thus generates welfare gains in an IU-regime. In an IS-regime, it intensifies competition for scarce consumer attention, which induces wasteful advertising, and it diverts demand to imported goods to the detriment of welfare.*

6 Further discussion

In Sections 2 and 3, we have introduced a perception constraint into an otherwise standard Melitz (2003) model to study the consequences of limited consumer attention for gains

[25] The negative welfare implications of advancements in ICT in an IS-regime can be moderated by an advertising tax. A non-discriminatory and internationally coordinated advertising tax, if optimally adjusted by the government, unambiguously generates welfare gains in the case of a general advancement in ICT. However, it needs not be successful in making an export-biased advancement in ICT beneficial, because it is not suited to directly target the distortionary diversion of purchases to imports when attention is scarce.

from international integration (brought about by falling unit costs of transport or ICT progress). Thereby, we have emphasized that the extensive margin of trade and the selection effects in the Melitz framework play an important role for welfare losses from integration if consumer attention is scarce. To substantiate this argument, it is worth looking at an otherwise identical framework with homogeneous producers, all of whom serving domestic as well as foreign consumers. This renders the dynamic model with fixed exporting costs considered in our paper akin to the static framework in Krugman (1980).

Since firms choose the exporting option voluntarily, serving foreign consumers must be associated with non-negative profits, i.e. $\tau^{1-\sigma} r/\sigma \geq a_x \rho^{\alpha}$. Furthermore, free entry of firms implies $(1+\tau^{1-\sigma})r/\sigma = a\rho^{\alpha}(1+a_x/a) + \delta f_e$. Combining $r = px$ with demand (1), $I = L$ (due to zero aggregate profits and $w = 1$), and $P^{1-\sigma} = M\left(1+\tau^{1-\sigma}\right)p^{1-\sigma}$, we can rewrite the free entry condition in the following way:

$$\frac{L}{\sigma M} = a\rho^{\alpha}\left(1+\frac{a_x}{a}\right) + \delta f_e. \tag{19}$$

In an IU-regime, the total mass of available product varieties, $M_t = 2M$, is smaller than the consumers' perception constraint, $\bar{M}$. In this case, we have $\rho = 1$, and the mass of domestic producers, M, is endogenously determined by Eq. (19). Similar to the model variant with heterogeneous firms with different export status, welfare $U = P^{-1}$ unambiguously increases in response to a fall in unit transport costs or an advancement in ICT if the capacity of consumers to gather and process information is not a limiting factor.

In an IS-regime the mass of domestic firms is determined by $M = \bar{M}/2$ and ρ adjusts endogenously to establish zero profits according to (19). In contrast to the model with heterogeneous producers with different export status, advertising effort ρ does not depend on the iceberg transport cost parameter, τ. As a consequence, there is no interaction between transport costs and competition for attention. Clearly, a fall in τ also cannot induce distortionary diversion to imports, if all goods are traded globally anyway. In sum, welfare unambiguously increases in response to a fall in the unit cost of transport. Furthermore, both general and export-biased improvements of ICT induce an increase in advertising strength ρ but leave the consumer price index and thus welfare unaffected, because they do not alter the export decision of incumbent producers. This highlights the role of the extensive margin of trade for generating losses from international integration, and Melitz (2003) provides a useful framework for studying this role in the context of heterogeneous firms.

Another feature of our model that deserves further discussion are the 'love-of-variety preferences', with consumers purchasing all available varieties in equilibrium. While this is a general property of models along the lines of Krugman (1980) and Melitz (2003), it is restrictive in our setting, as it rules out one potentially important form of welfare loss in the presence of constrained perception: Distraction of an agent's attention on products that he or she does not want to consume. There is no doubt that we are confronted with a lot of – from our perspective – useless advertising (commonly referred to by the term 'junk'). It is thus of interest to see how the insights from our analysis change if we additionally account for this possibility. Falkinger (2008b) provides a useful starting point for studying the role of junk in a limited attention model, and we now show how the model outlined in Sections 2 and 3 can be extended to capture the welfare losses associated with distraction of attention on junk.

For this purpose, let us assume that there are two types of consumers, $i = 1, 2$, who differ in their assessment of goods. Products can be classified according to the utility they provide to the two types of agents and, for simplicity, we assume that products from category i are associated with positive utility of consumers i, while useless for other ones, i.e. for consumers $-i \neq i$. In this case, consumers from subgroup $-i$ will not purchase goods from category i, irrespective of the price they are confronted with. If consumers would have perfect knowledge about all goods, they would clearly pay only attention to the preferred ones and ignore any advertisements on products they considered as useless. However, the very reason for why we have an attention model and why advertising plays a role in the first place is that ex ante consumers are not fully informed about the available products. Hence, it is impossible to filter advertisements perfectly according to consumers' preferences, without paying some attention also to those products which ex post turn out to be useless.

To see the implications of those principle limitations in their clearest form, we disregard any filtering and assume that consumers allocate their attention randomly on all advertisements. For the producer of a particular product, this means that all consumers must be addressed with sufficient strength to attract their attention, but only part of them will purchase the product. This gives us an attention model whose properties are similar to the one studied in the previous sections and, at the same time, accounts for the distraction of attention on products that actually are useless from the perspective of consumers. Of course, the distraction of attention does only trigger welfare losses if the perception constraint is binding, because it is only in this case that attention which is allocated on

junk crowds out attention for products that have a positive value for consumers.

The pure existence of welfare losses due to exposure to junk does not change our insights upon the role of limited consumer attention for the gains from trade identified in the previous analysis. This can easily be seen if we imagine a situation in which everything is symmetric: Populations of type 1 and 2 consumers are of equal size, firms assigned to the two categories draw productivity from the same distribution, and countries are symmetric in all respects. Then, economic integration will not change the composition of goods from the two product categories and will therefore leave the exposure to junk unaffected in an IS-regime. Hence, the only thing which changes compared to the analysis in the previous sections is for producers, that sales for a successfully advertised product are cut by half, and for consumers, that only half of the perceived products are relevant for the pleasure enjoyed by love of variety. For the competition for attention and thus for selection effects and entry decisions nothing changes qualitatively, so that the insights from the previous analysis are not altered in an essential way.

This changes if we allow for asymmetries in the two countries' population of type 1 and type 2 consumers. Suppose, for instance, that one country is populated only by type 1 consumers, whereas in the other country the population is split into one half of type 1 consumers and one half of type 2 consumers. Then, international integration will change the composition of available products in the country with both types of consumers with the effect that type 2 consumers experience more junk and type 1 consumers less of it. The consumers in the other country experience no junk anyway, since no type 2 producer will enter the market. In sum, with an asymmetry of this form and the perception constraint being binding, further economic integration aggravates the attention distraction problem for one subgroup, while lowering it for the other one. This has two notable implications. First, the widespread concern that in recent years the magnitude of junk in advertisement has enormously increased does not necessarily refer to a general impression of all consumers. Second, there are two counteracting effects on the distraction of attention with the total implications for aggregate welfare depending *inter alia* on the relative size of the two subgroups of consumers.[26]

[26] A further reason why trade may exacerbate the attention distraction problem is a bias of consumer preferences towards domestic products.

7 Concluding remarks

This paper has introduced the idea of limited consumer attention into a new trade theory model with love-of-variety preferences and heterogeneous firms. In this setting, we have shown that access to new foreign varieties does not necessarily provide gains from trade. The existence of a positive welfare effect from trade liberalization crucially depends on whether an economy is in an information-unsaturated or in an information-saturated regime. In the former case, a decline in transport costs raises both the mass of consumed varieties and the cutoff productivity level, thereby triggering positive welfare effects as in other new trade theory models with heterogeneous producers. In the latter case, firms raise their advertising expenditures in response to lower transport costs in order to reach consumers in the then fiercer competition for their limited attention. This exerts a negative externality on a firm's competitors and reinforces the selection effect at the bottom of the productivity distribution. While the rise in the productivity level of active firms is beneficial, the increased advertising efforts, which triggered the additional selection effects, are a waste of resources. The negative effect of wasteful advertising is complemented by a second distortionary effect: Under scarcity of attention, the love-of-variety gains from trade cannot be exploited and compensate for the transport costs of additional imports. This induces inefficient diversion of consumer purchases to imports. In sum, a decline in unit costs of transport can have negative effects on welfare in an information-saturated economy.

We have also studied the scope for policy intervention and have shown that setting an internationally coordinated and non-discriminatory advertising tax is indeed a remedy for the problem of wasteful advertising triggered by competition for attention. If the tax is set optimally, the waste of advertising resources can be eliminated completely, whereby the optimal tax increases with integration. But even under an optimal advertising tax, the problem of inefficient diversion of purchases to imports, which arises under limited attention, remains a source of welfare loss. Hence, an optimal adjustment of the advertising tax to changes in transport costs need not be sufficient to ensure gains from trade. In an information-unsaturated regime the perception constraint of consumers is not binding and firm entry is efficient, so that there is no need for policy makers to intervene with a (positive or negative) tax on advertisement.

In a further step of our analysis, we have looked at the consequences of advancements in information and communication technologies which ease the dissemination of advertise-

ment information. We have shown that the welfare implications of such an advancement depend on two factors: the scarcity of consumer attention and the export bias in the technology improvement. If the economy is in an information-unsaturated regime, both a general and an export-biased advancement in ICT – despite exerting different effects on the cutoff productivity level – lead to an increase in the mass of available product variants and thus enhance welfare. On the contrary, in an information-saturated regime, firms raise their advertising strength in response to an advancement in ICT. In the case of a general advancement, the firm-level adjustment in the advertising strength exactly offsets the direct positive effect of falling advertising costs, thereby leaving the productivity cutoff, the mass of available domestic and imported varieties as well as welfare at their initial levels. If the ICT advancement is export biased, its implications are even less encouraging. By reinforcing selection at the bottom of the productivity distribution and diverting demand to imports, an export-biased advancement in ICT unambiguously lowers welfare.

In an extension, we have discussed two possible modifications of our framework. On the one hand, we have considered homogeneous (instead of heterogeneous) firms, all of them exporting to the foreign economy. We have shown that in this modified framework falling unit costs of transport are always welfare-improving, irrespective of whether consumer attention is scarce. ICT advancements are beneficial in an information-unsaturated regime, while they have no welfare effect in an information-saturated regime. This shows that selection into exporting in the presence of heterogeneous producers is essential for welfare losses in our model. On the other hand, we have modified preferences to abandon the restrictive assumption that consumers purchase all goods. To be more specific, we have distinguished consumers according to their assessments of goods and have assumed that consumption of a specific type of goods needs not be beneficial for all consumers. We have shown that the main insights regarding the effects of international integration from our analysis remain unaffected by this modification if consumers allocate their attention randomly on advertisements and everything is symmetric. However, the existence of junk – this means advertisement information about products which are useless for a consumer – clearly leads to additional welfare losses in an information-saturated environment, and these losses may be different for different consumers.

While the main purpose of this paper is setting up a simple, analytically tractable framework for studying the consequences of limited consumer attention in the context of international trade, our analysis also provides insights for empirical research. In particular, the model highlights that import of new varieties generates a crowding out of domesti-

cally produced varieties and that this crowding out may be sufficiently strong to induce welfare losses. Hence, by exclusively looking at changes in the number of imported varieties, empirical research may significantly over-estimate the welfare gains of trade (see, for instance, Broda and Weinstein, 2004, 2006). Unfortunately, data on the total mass of domestically produced varieties is usually not available, so that the crowding out effect cannot be directly observed. However, according to our model, the size of the crowding out effect is a function of trade costs and advertising expenditures. To be more specific, the model predicts that the crowding out effect is strong if total advertising expenditures relative to GDP increase in response to the import of new varieties (and even more so if the surge in advertising is primarily due to importers). Taking stock, our model suggests that better estimates for the gains from imported varieties can be obtained if one accounts for the endogenous adjustment in advertising expenditures relative to GDP and its consequences for the crowding out of domestic firms.

Of course, all of our results have to be interpreted under the usual caveat that a single model cannot capture all facets of the real world. However, with the average consumer in the OECD being exposed to 3000 ads a day (Love and Lattimore, 2009), it is important to take the limitations in the consumers' capacity to gather and process information seriously also in the trade literature. A better understanding of these limitations will lead us to a more realistic picture about the consequences of international integration and its challenges for economic policy. While more research on this topic is certainly needed, we hope that our analysis provides a useful first step for modeling limited consumer attention in an international trade context and for stimulating new empirical research on the gains from imported varieties.

Appendix

Derivation details for Eq. (3)

Note that *domestic* profits of exporters and non-exporters are given by

$$\pi(\phi) = \frac{r(\phi)}{\sigma} - f = f\left[\frac{r(\phi)}{r(\phi^*)} - 1\right] = f\left[\left(\frac{1}{\phi}\right)^{1-\sigma}(\phi^*)^{1-\sigma} - 1\right], \tag{20}$$

where $\pi(\phi^*) = 0$ and $r(\phi)$ from Footnote 10 have been used. Note further that for the Pareto distribution $\mathbb{E}[\phi^{-z}] = k/(k+z)$, if $k > -z$, and use $\mathbb{E}[\phi^{-z}|\phi \geq \phi^*] = (\phi^*)^{-z}\mathbb{E}[\phi^{-z}]$. Setting $z = 1 - \sigma$ and substituting the resulting expression into (20), we can compute

average domestic profits of all active producers: $\bar{\pi} = f(\sigma-1)/[k-\sigma+1]$. In an analogous way, *exporting* profits can be calculated, noting that exporting revenues are $r_x(\phi) = \tau^{1-\sigma} r(\phi)$, whereas exporting fixed costs are f_x. This gives $\bar{\pi}_x = f_x(\sigma-1)/[k-\sigma+1]$. Since only a share χ of firms export, average total profits are given by $\bar{\pi}_t = \bar{\pi} + \chi\bar{\pi}_x$, which can be written in the form of Eq. (3).

Derivation details for Eq. (5)

The cost-of-living (CES) price index is given by

$$\begin{aligned} P &= \left[M \int_{\phi^*}^{\infty} p(\phi)^{1-\sigma} \frac{dG(\phi)}{1-G(\phi^*)} + \chi M \int_{\phi_x^*}^{\infty} (\tau p(\phi))^{1-\sigma} \frac{dG(\phi)}{1-G(\phi_x^*)} \right]^{\frac{1}{1-\sigma}} \\ &= \left[\frac{Mk\left(1+\chi\tau^{1-\sigma}(\phi_x^*/\phi^*)^{\sigma-1}\right)}{k-\sigma+1} \right]^{\frac{1}{1-\sigma}} p(\phi^*), \end{aligned} \tag{21}$$

where the properties of the Pareto distribution, which were mentioned above, have been exploited. Substituting $(\phi_x^*/\phi^*)^{\sigma-1} = (f_x/f)\tau^{\sigma-1}$, $M = M_t/(1+\chi)$, using $I = L$, and noting that $U = P^{-1}$, we get

$$U = \left[\frac{M_t k}{k-\sigma+1} \frac{1+\chi f_x/f}{1+\chi} \right]^{\frac{1}{\sigma-1}} p(\phi^*)^{-1}, \tag{22}$$

which, in view of (4), can be simplified to

$$U = \left[\frac{L}{\sigma f} \right]^{\frac{1}{\sigma-1}} p(\phi^*)^{-1}. \tag{23}$$

Solving (2) and (3) for ϕ^* and substituting the resulting expression into $p(\phi^*) = [\sigma/(\sigma-1)](\phi^*)^{-1}$, we obtain

$$p(\phi^*) = \frac{\sigma}{\sigma-1} \left[\left(1+\chi\frac{f_x}{f}\right) \frac{(\sigma-1)f}{(k-\sigma+1)\delta f_e} \right]^{-\frac{1}{k}}. \tag{24}$$

Using the latter in (23), we finally have (5).

Derivation details for Eq. (11)

Let $\rho \equiv \rho(\chi, M_t)$ be implicitly defined by (4′). Then, substitution of (6) for f and f_x into (5) and differentiation of the resulting expression with respect to τ gives us

$$\left.\frac{dU}{d\tau}\right|_{\rho=\rho(\chi,\bar{M})} = \left[\left.\frac{\partial U}{\partial \rho}\right|_{\rho=\rho(\chi,\bar{M})} \times \left.\frac{\partial \rho}{\partial \chi}\right|_{M_t=\bar{M}} + \left.\frac{\partial U}{\partial \chi}\right|_{\rho=\rho(\chi,\bar{M})} \right] \frac{d\chi}{d\tau}. \tag{25}$$

Accounting for (9) and using

$$\left.\frac{\partial U}{\partial \rho}\right|_{\rho=\rho(\chi,\bar{M})} = -\frac{\alpha U}{\rho(\chi,\bar{M})k}\frac{k-\sigma+1}{\sigma-1}, \tag{26}$$

we obtain

$$\left.\frac{\partial U}{\partial \rho}\right|_{\rho=\rho(\chi,\bar{M})} \times \left.\frac{\partial \rho}{\partial \chi}\right|_{M_t=\bar{M}} = -\frac{U(1-a_x/a)}{k(1+\chi)(1+\chi a_x/a)}\frac{k-\sigma+1}{\sigma-1}. \tag{27}$$

Substituting the latter together with

$$\left.\frac{\partial U}{\partial \chi}\right|_{\rho=\rho(\chi,\bar{M})} = \frac{(a_x/a)U}{k(1+\chi a_x/a)}, \tag{28}$$

into (25) and rearranging terms, establishes Eq. (11).

Welfare effects of trade liberalization under optimal advertising taxation

In the subsequent, we analyze how a decline in the transport cost parameter affects welfare in an IS-regime if the government adjusts its tax policy optimally. For this purpose, we can first note that setting $M_t = \bar{M}$ in Eq. (4″) yields

$$\frac{L+T}{\sigma a \rho^{\alpha}(1+t)} = \frac{k\bar{M}}{k-\sigma+1}\frac{1+\chi a_x/a}{1+\chi}. \tag{29}$$

We can also use (4″) to compute

$$(1+\chi a_x/a)a\rho^{\alpha}(1+t) = \frac{k-\sigma+1}{\sigma k}\frac{(1+\chi)(L+T)}{\bar{M}} \tag{30}$$

Substituting $\hat{t}$ from (17) into (4″) and accounting for $\rho = 1$ gives

$$T = t\bar{M}a\frac{1+\chi a_x/a}{1+\chi} = \frac{L(k-\sigma+1)-\sigma k\bar{M}a(1+\chi a_x/a)/(1+\chi)}{(k+1)(\sigma-1)}$$

and thus

$$L+T = \frac{k\sigma}{(k+1)(\sigma-1)}\left[L-\bar{M}a\frac{1+\chi a_x/a}{1+\chi}\right]. \tag{31}$$

Substitution of the expressions above into Eq. (5′) gives

$$U = B\,(1+\chi)^{\frac{1}{k}}\left(\frac{1+\chi a_x/a}{1+\chi}\right)^{\frac{1}{\sigma-1}}\left[L-\bar{M}a\frac{1+\chi a_x/a}{1+\chi}\right]^{\frac{k+1}{k}}, \tag{32}$$

with

$$B \equiv \frac{k}{(k+1)L}\left(\frac{k\bar{M}}{k-\sigma+1}\right)^{\frac{1}{\sigma-1}}\left[\frac{1}{(k+1)\bar{M}\delta f_e}\right]^{\frac{1}{k}}.$$

By definition, an economy is in an IS-regime if the right-hand side of Eq. (4) exceeds $\bar{M}$ at $\rho = 1, t = 0$. Rearranging terms, we can formulate $L(1+\chi)(k-\sigma+1)/(\sigma k) > \bar{M}a(1+\chi a_x/a)$ and, in view of $k-\sigma+1 < k\sigma$, $L(1+\chi) > \bar{M}a(1+\chi a_x/a)$ as a requirement for an IS-regime. This implies that (32) is positive.

Differentiating (32) with respect to τ, we obtain

$$\frac{dU}{d\tau} = A(\chi)\left[\left(1-\frac{(1-a_x/a)k}{(1+\chi a_x/a)(\sigma-1)}\right)\left(L-\bar{M}a\frac{1+\chi a_x/a}{1+\chi}\right) + \frac{(k+1)\bar{M}a(1-a_x/a)}{1+\chi}\right]\frac{d\chi}{d\tau}, \tag{33}$$

with

$$A(\chi) \equiv \frac{U}{k\left[L(1+\chi)-\bar{M}a(1+\chi a_x/a)\right]} > 0.$$

Note that $A(\chi) > 0$ follows from $L(1+\chi) > \bar{M}a(1+\chi a_x/a)$, which must hold in an IS-regime (see above). From (12) it follows that $\tau \leq \bar{\tau}$ is equivalent to

$$\frac{k(1-a_x/a)}{(1+\chi a_x/a)(\sigma-1)} \leq 1, \tag{34}$$

which, in view of $d\chi/d\tau < 0$, is sufficient (not necessary) for $dU/d\tau < 0$. We can thus conclude that in an IS-regime $\tau \leq \bar{\tau}$ is sufficient (not necessary) for a positive welfare effect of a marginal decline in transport cost parameter τ if the government adjusts its tax rate according to (17). However, positive welfare effects of trade liberalization are not guaranteed if $\tau > \bar{\tau}$. In this case, the first component in the square bracket of (33) is negative, and a marginal decline in τ lowers welfare if $\bar{M}$ is sufficiently small.

Derivation details for Eq. (18)

Setting $t = 0$ and differentiating Eq. (14) with respect to a_x gives

$$\frac{d\rho}{da_x} = \frac{\partial\rho}{\partial a_x} + \frac{\partial\rho}{\partial\chi}\frac{d\chi}{da_x}. \tag{35}$$

Accounting for

$$\frac{\partial\rho}{\partial a_x} = -\frac{\rho}{\alpha}\frac{\chi}{a(1+\chi a_x/a)}, \qquad \frac{\partial\rho}{\partial\chi} = \frac{\rho}{\alpha}\frac{1-a_x/a}{(1+\chi a_x/a)(1+\chi)} \tag{36}$$

and noting that $\chi = \left[(a_x/a)\tau^{\sigma-1}\right]^{-k/(\sigma-1)}$ implies $d\chi/da_x = -[k/(\sigma-1)]\chi/a_x$, we can rewrite Eq. (35) in the following way:

$$\frac{d\rho}{da_x} = -\frac{\rho}{\alpha}\frac{\chi}{a(1+\chi a_x/a)} - \frac{\rho}{\alpha}\frac{k}{\sigma-1}\frac{(1-a_x/a)\chi}{a_x(1+\chi a_x/a)(1+\chi)}. \tag{37}$$

Rearranging terms, finally gives Eq. (18).

The implications of ICT advancements

General ICT-advancement

Let us first consider the effect of a *pari passu* decline in both a and a_x. Setting $\rho = 1$ and differentiating (4′) with respect to a (holding a_x/a constant), we find that $dM_t/da < 0$ holds in an IU-regime. In contrast, setting $M_t = \bar{M}$, we conclude from (4′) that, for a given a_x/a, $d\rho/da < 0$, while $a\rho^\alpha = const.$ in an IS-regime. The welfare effects of a general advancement in ICT follow immediately from $dU/df < 0$ due to $k > \sigma - 1$, when keeping f_x/f constant (see Eq. (5)). With $f = a\rho^\alpha$ rising in a in an IU-regime, in which $\rho = 1$, while remaining constant in the IS-regime, we confirm that a general advancement in ICT raises welfare under IU and has no effect under IS.

Export-biased ICT-advancement

The impact of an export-biased ICT change on M_t in an IU-regime can be determined by setting $\rho = 1$ and differentiating (4′) with respect to a_x. This gives

$$\frac{dM_t}{da_x} = \frac{\partial M_t}{\partial \chi}\frac{d\chi}{da_x} + \frac{\partial M_t}{\partial a_x} = -\frac{M_t}{1+\chi a_x/a}\frac{\chi}{a_x}\left[\frac{k}{\sigma-1}\frac{1-a_x/a}{1+\chi} + \frac{a_x}{a}\right], \tag{38}$$

and hence $dM_t/da_x < 0$ in an IU-regime. In an IS-regime, we have $M_t = \bar{M}$ and ρ responds to changes in a_x according to (18).

The welfare implications of an export-biased ICT change in an IU-regime can be determined by substituting (6) and $\rho = 1$ into (5) and differentiating the resulting expression by a_x. This gives

$$\frac{dU}{da_x} = \frac{\partial U}{\partial \chi} \times \frac{d\chi}{da_x} + \frac{\partial U}{\partial a_x}, \tag{39}$$

which – by using (28) and $d\chi/da_x = -k\chi/[(\sigma-1)a_x]$ for $\partial U/\partial\chi \times d\chi/da_x$, and (5) for computing $\partial U/\partial a_x = U\chi/[ak(1+\chi a_x/a)]$ – can be rewritten as

$$\frac{dU}{da_x} = -\frac{U\chi/a}{k(1+\chi a_x/a)}\frac{k-\sigma+1}{\sigma-1} < 0. \tag{40}$$

Hence, an export-biased advancement in ICT generates welfare gains in an IU-regime.

In an IS-regime, $\rho \equiv \rho(\chi, \bar{M})$ is given by (14), when setting $t = 0$, and the impact of a change in technology parameter a_x is determined by

$$\left.\frac{dU}{da_x}\right|_{\rho=\rho(\chi,\bar{M})} = \left.\frac{\partial U}{\partial \rho}\right|_{\rho=\rho(\chi,\bar{M})} \times \left.\frac{d\rho}{da_x}\right|_{M_t=\bar{M}} + \left.\frac{\partial U}{\partial \chi}\right|_{\rho=\rho(\chi,\bar{M})} \times \frac{d\chi}{da_x} + \left.\frac{\partial U}{\partial a_x}\right|_{\rho=\rho(\chi,\bar{M})}, \quad (41)$$

which – by using (18) and (26) for $\partial U/\partial \rho|_{\rho=\rho(\chi,\bar{M})} \times d\rho/da_x|_{M_t=\bar{M}}$, (28) and $d\chi/da_x = -k\chi/[(\sigma-1)a_x]$ for $\partial U/\partial \chi|_{\rho=\rho(\chi,\bar{M})} \times d\chi/da_x$, and (5) for computing $\partial U/\partial a_x|_{\rho=\rho(\chi,\bar{M})} = U\chi/[ak(1+\chi a_x/a)]$ – can be reformulated to

$$\left.\frac{dU}{da_x}\right|_{M_t=\bar{M}} = \frac{U\chi/a_x}{(\sigma-1)(1+\chi a_x/a)} \frac{k-\sigma+1}{\sigma-1} \frac{1-a_x/a}{1+\chi} > 0, \quad (42)$$

implying that an export-biased advancement in ICT lowers welfare in an IS-regime. This completes the formal discussion upon the consequences of advancements in information and communication technologies.

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