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Positive welfare effects of trade barriers in a dynamic equilibrium model*

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Abstract

We develop a simple two-region, cobweb-type dynamic equilibrium model to demonstrate the existence of optimal trade barriers. A pure comparative statics analysis of our model suggests that a reduction of trade barriers always enhances welfare. However, taking a dynamic perspective reveals that nonlinear trade interactions between the two regions may generate endogenous price fluctuations which can hamper both consumer and producer surplus. Finally, we allow special interest groups, such as consumers or producers from the two regions, to lobby for a particular level of trade barriers. Our model predicts that time-varying trade barriers may be another channel for market instability.

Keywords: cobweb dynamics, market interactions, optimal import tariffs, welfare analysis, political economy of trade barriers

JEL Classification: D72, F13, H21

1 Introduction

Conventional economic wisdom teaches us that trade barriers have a negative impact on allocative efficiency.[1] While protectionist policies may be beneficial to specific groups, aggregate welfare is typically best promoted by free trade. This conclusion is

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[1]See the famous models of comparative advantage by Ricardo (Ricardo, 1963) and Heckscher and Ohlin (Ohlin, 1933, Samuelson, 1948). For a textbook introduction into models of international trade, see e.g. Krugman and Obstfeld (2011).

based upon a comparative statics approach where steady state allocations with and without barriers to trade are compared. Such an analysis seems to be reasonable as long as these steady state allocations are stable and give a good description of the trading patterns that emerge.

In general, however, it may be that the stability properties of the steady state allocations are affected by trade barriers. For example, free trade may induce larger swings in supply of a certain commodity in, say, the domestic market, since a perceived profit opportunity will attract more foreign suppliers. This increase in supply elasticity may destabilize the domestic commodity market and lead to higher volatility of prices, consumption levels and firm profits than when there are sufficient trade barriers. The higher volatility will be detrimental to welfare such that typically a trade off between higher allocative efficiency at the steady state and welfare decreasing volatility may emerge.

In this paper, we investigate this trade off by considering a simple equilibrium model with two regions, region A and region B. In each region the same homogeneous commodity is produced and consumed, but in the absence of trade relations the steady state equilibrium price in region A is smaller than in region B. This may be either due to differences in the number of firms or the cost efficiency of those firms in the two regions, or by differences in the demand for the commodity in the two regions. In either case, firms from region A will have an incentive to export their commodity to region B where they may receive a higher price. However, these firms may face trade barriers which we model as small but positive import tariffs.

We consider a behavioral model where firms from region A decide on the basis of past profits in which market they want to supply their product in the next period. As there is a production lag the production decision of all firms has to be based upon their price expectations, which are formed on the basis of past prices. In this setting we study the effect of import tariffs that region B imposes upon the supply from region A on price stability and aggregate welfare. We find that relaxing trade barriers may indeed induce instability and thereby decrease aggregate welfare. As a consequence, and in contrast to conventional economic wisdom, there may be an optimal and non-zero level of barriers to trade in such an environment. We extend the analysis by considering the political economy of trade policy. In particular, we will allow special interest groups (specifically the consumers and producers from region B) to lobby for a decrease or increase in the import tariffs, respectively. We study the impact of these lobbying efforts on the dynamics and find that it presents another channel for instability.

The mechanism driving instability in our model is closely related to and inspired by the one studied in Dieci and Westerhoff (2009, 2010). They consider an economic environment with two cobweb markets that are stable when isolated from each other but that may become unstable when there are interactions and suppliers can move between markets. In Dieci and Westerhoff (2009, 2010), however, there is only a comparison between the scenarios of full isolation and full interaction, whereas in the current paper the level of import tariffs determines exactly the extent to which markets interact. More importantly, we are motivated by analyzing the welfare aspects of changes in these import tariffs.

Although our results remain – to a certain extent – valid under rational price expectations, we assume that firms use simple prediction rules, such as naive and adaptive expectations. We believe this is relevant because there is empirical (see e.g. Baak, 1999, and Chavas, 2000) as well as experimental evidence (Sonnemans et al., 2004 and Hommes et al., 2007) that suggests that human decision makers indeed use simple prediction strategies.

Similar in spirit to our paper is the contribution by Commendatore and Kubin (2009) who identify a similar type of trade off between allocative efficiency and stability. They study labor and product market deregulations in a general equilibrium model with monopolistic competition and show that, although these deregulations increase equilibrium employment, they may also lead to instability and endogenous fluctuations.

Crucial to our results is the trade off, associated with a decrease in import tariffs, between the increase in welfare due to higher allocative efficiency in the steady state and the potential decrease in welfare because of the emergence of endogenous fluctuations. At the outset, however, it is not obvious that volatility in prices and consumption levels is actually detrimental to aggregate welfare. Lucas (1987), for example, claims that the negative welfare effects of business cycles are relatively small – a conclusion that has led to a substantial literature, and has been challenged by others (see e.g. Barlevy, 2004 and Jung and Kuester, 2011). Moreover, Matsumoto (1999), Matsumoto and Nonaka (2006) and Huang (2008) show, in nonlinear cobweb and Cournot models, that chaotic fluctuations may increase profits of all firms and may even lead to increases in aggregate welfare. In our setting, however, fluctuations typically have a substantial negative effect on aggregate welfare.

Although our results are entirely theoretical there is some empirical evidence that is consistent with our findings. For example, Cashin and McDermott (2002) find that real commodity prices have become more volatile over time. Although the relationship between trade openness and output volatility is ambiguous, Karras and Song (1996) provide empirical evidence of a positive correlation between the two. Moreover, Bordo et al. (2001) show that financial and economic crises occur more frequently than in the past and explain this by an increase in deregulation. The current financial and economic crisis sadly confirms how interdependent and fragile the world's markets are.

The remainder of this paper is structured as follows. In Section 2 we describe the steady state equilibria of the model under autarky, free trade and trade barriers. Stability properties of the steady state equilibrium are investigated in Section 3. In Section 4 the welfare aspects of a decrease in import tariffs are explored and in Section 5 we discuss the political economy of import tariffs. Concluding remarks are provided in Section 6 and the Appendix contains proofs of some of the main results.

2 Steady state market equilibria in a two-region model

In this section we outline our basic economic model of trade between two related markets and characterize the steady state equilibria that emerge under different trading policies. We consider a homogeneous product that is sold on two markets, A and B. Demand for the product on these markets is given by well-behaved downward sloping demand functions $D_A(p_A)$ and $D_B(p_B)$, respectively. The two markets could for example correspond to different countries, different regions, or different sectors. Firms in market A (B) face an upward sloping convex cost function $c_A(q)$ ($c_B(q)$). We assume that firms on each market are price-takers, implying that an individual firm in market A has supply function $q_A = S_A(p_A) = (c'_A)^{-1}(p_A)$ and an individual firm in market B has supply function $q_B = S_B(p_B) = (c'_B)^{-1}(p_B)$. The number of firms in the two markets are denoted by n_A and n_B, respectively. Thus, the total number of firms is given by $n = n_A + n_B$.

The remainder of this section characterizes the relevant steady state equilibria that may occur in this economic environment. In Subsection 2.1 we discuss the *autarkic* equilibrium, that is the steady state equilibrium that emerges if no trade between the two regions is possible. The steady state equilibrium under free trade is considered in Subsection 2.2. Finally, we investigate the effect of import tariffs on the steady state equilibrium in Subsection 2.3.

2.1 Autarky

We denote the situation where the two markets function completely independent from each other, for example because import tariffs are prohibitively high, by *autarky*. In that case the market equilibrium is given by prices p_A^a and p_B^a such that

$$D_A(p_A^a) = n_A S_A(p_A^a) \text{ and } D_B(p_B^a) = n_B S_B(p_B^a).$$

Without loss of generality we assume that $p_B^a > p_A^a$. This could be because demand in market B is larger, firms in market A are more efficient, the number of firms in market A is larger than the number of firms in market B or a combination of the above.

Figure 1 illustrates the autarkic market equilibrium. For numerical simulations later on we will use a linear specification. Demand functions are represented by

$$D_A(p_A) = a - p_A \text{ and } D_B(p_B) = b - p_B,$$

where $a, b > 0$. Firms producing commodity A and B have identical quadratic cost functions

$$c_A(q) = \frac{1}{2}q^2 \text{ and } c_B(q) = \frac{1}{2}q^2.$$

Under perfect competition an individual firm's supply is given by $S_i(p_i) = (c'_i)^{-1}(p_i) = p_i$ with $i = A, B$.

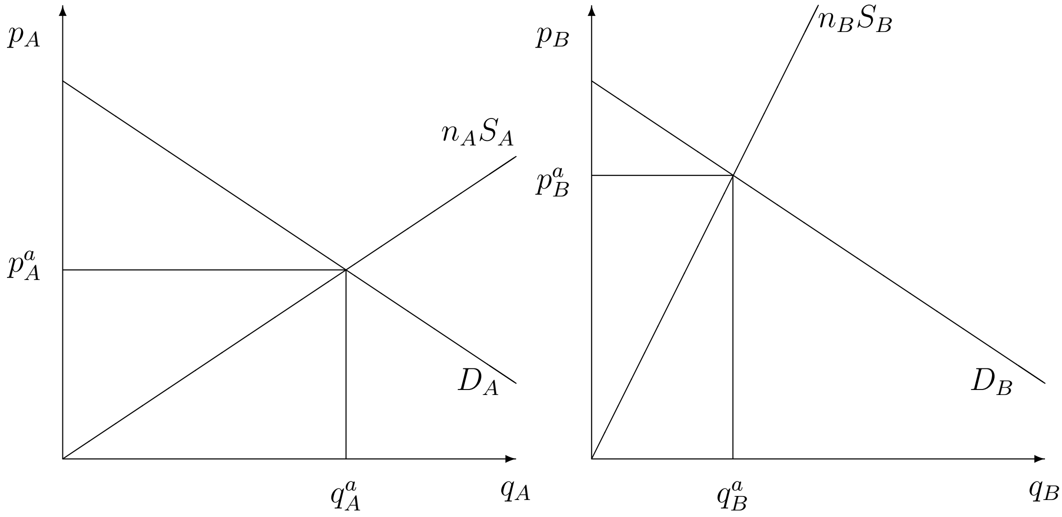

Figure 1: The autarkic market equilibrium

It is easy to verify that *autarkic* equilibrium prices are given by

$$p_A^a = \frac{a}{1+n_A} \text{ and } p_B^a = \frac{b}{1+n_B},$$

with autarkic (aggregate) equilibrium quantities

$$q_A^a = n_A \frac{a}{1+n_A} \text{ and } q_B^a = n_B \frac{b}{1+n_B}.$$

Total profits and aggregate consumer surplus in region A can be expressed as $\pi_A^a = n_A \left(p_A q_{Ai} - \frac{1}{2} q_{Ai}^2\right) = \frac{1}{2} n_A \left(p_A^a\right)^2$ and $CS_A^a = \frac{1}{2}\left(q_A^a\right)^2$. Similarly, we obtain for region B $\pi_B^a = \frac{1}{2} n_B \left(p_B^a\right)^2$ and $CS_B^a = \frac{1}{2}\left(q_B^a\right)^2$. We will make the assumption that

$$b\left(1+n_A\right) > a\left(1+n_B\right),$$

which implies that autarkic equilibrium prices and individual profits are larger in region B than in region A, as depicted in Figure 1. This can be either due to larger demand in region B (high demand parameter b) or more competition in region A (higher number of firms n_A), or both.

2.2 Free trade

Now assume that firms in region A are allowed to supply their product in market B where they can obtain a higher price. Abstracting from transportations costs, prices p_A and p_B will be equal in the new equilibrium, making profit opportunities the same in each region. The free trade equilibrium price $\widehat{p}$ satisfies

$$D_A\left(\widehat{p}\right) + D_B\left(\widehat{p}\right) = n_A S_A\left(\widehat{p}\right) + n_B S_B\left(\widehat{p}\right).$$

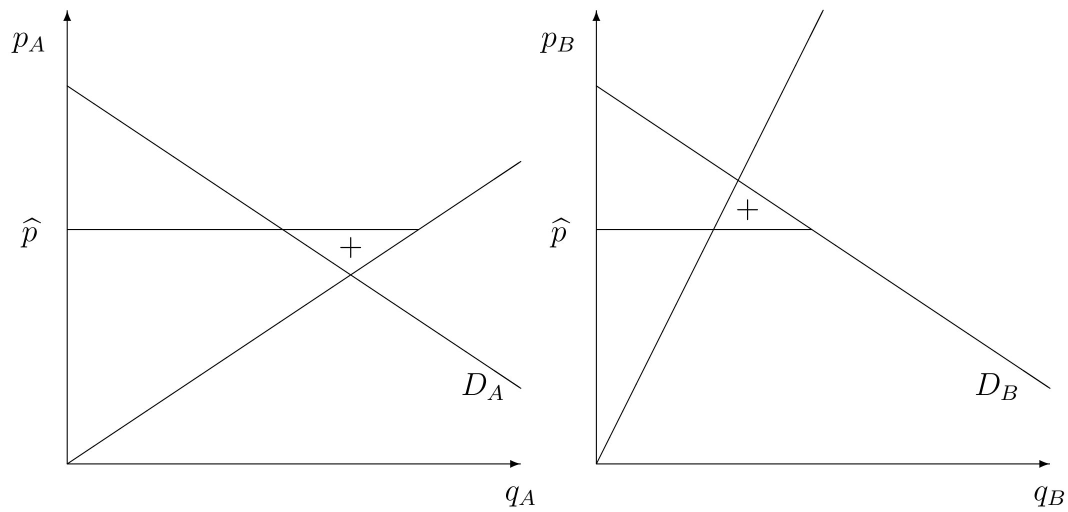

Figure 2: Market equilibrium under free trade.

The market equilibrium under free trade is illustrated in Figure 2.

We have the following straightforward and well known result (the proof of which can be found in Appendix A):

Lemma 1 *The equilibrium prices satisfy $p_B^a > \widehat{p} > p_A^a$. Moreover, total surplus (i.e., the sum of consumer and producer surplus) goes up for both regions.*

In Figure 2 the increase in total surplus in each region is indicated by the '+'-symbol. Note that moving from autarky to free trade is *not* a Pareto improvement. In particular, although consumers in B and producers in A are better off (the former now pay lower prices, whereas the latter receive higher prices) consumers in A (paying higher prices) and producers in B (receiving lower prices) are worse off than before. However, in the aggregate each region benefits from free trade.

For our specification, we obtain

$$\widehat{p} = \frac{a+b}{2+n_A+n_B}.$$

Since $b\,(1+n_A) > a\,(1+n_B)$ it follows that $p_B^a > \widehat{p} > p_A^a$. Due to free trade, some firms in region A will supply their product in region B which leads to an increase in supply (and decrease in price) in region B and, of course, to the opposite effect in region A.

Equilibrium output in the two countries under free trade are now determined by

$$q_A^F = \frac{a-b+a\,(n_A+n_B)}{2+n_A+n_B} \text{ and } q_B^F = \frac{b-a+b\,(n_A+n_B)}{2+n_A+n_B}.$$

Moreover, total profits of firms from region A (region B) follow as $\Pi_A^F = \frac{1}{2} n_A (\widehat{p})^2$ ($\Pi_B^F = \frac{1}{2} n_B (\widehat{p})^2$) and consumer surplus in region A and B can be expressed as

$$CS_A^F = \frac{1}{2}\left(\frac{a-b+a(n_A+n_B)}{2+n_A+n_B}\right)^2 \text{ and } CS_B^F = \frac{1}{2}\left(\frac{b-a+b(n_A+n_B)}{2+n_A+n_B}\right)^2.$$

Comparing free trade with autarky we find that firms from region A are better off under free trade since the price for their product has gone up. In contrast, profits for firms in region B go down, due to fiercer competition resulting in lower prices. Similarly, consumers in country A are worse off, while consumers in country B are better off. It is straightforward to verify that aggregate firm profits decrease and aggregate consumer surplus increases if we move from autarky to free trade.

2.3 Import tariffs

Now we consider the intermediate case where barriers to entry exist that are not necessarily entirely prohibitive. To be specific, firms from region A that supply their product in region B need to pay a **tariff** $\tau \in [0,1]$.[2] That is, given the consumer price p_B in region B they receive $p_B(1-\tau)$ for any unit sold in region B.

Let $\xi \in [0, n_A]$ be the number of firms from region A supplying in region B. Market equilibrium prices $p_A(\xi)$ and $p_B(\xi,\tau)$ for given values of ξ and τ now satisfy

$$D_A(p_A) = (n_A - \xi) S_A(p_A) \text{ and } D_B(p_B) = n_B S_B(p_B) + \xi S_A(p_B(1-\tau)). \quad (1)$$

Typically $p_A(\xi)$ will increase in ξ (since the number of firms that are active in region A decreases with ξ) and $p_B(\xi,\tau)$ will decrease in ξ (since supply in region B increases with ξ). Moreover, $p_B(\xi,\tau)$ will increase in τ (for a given value of ξ) since the individual supply of each of the ξ firms from region A that are active in region B decreases with τ.

Figure 3 illustrates the market equilibrium that will emerge, for a given value of $\xi \in (0, n_A)$. The supply curve in region A shifts to the left since some domestic firms now supply their product in region B. For the same reason the supply curve for region B shifts to the right. Consequently, comparing with autarkic equilibrium prices, the equilibrium price in region A goes up and that in region B goes down.

Moreover, in a steady state equilibrium ξ should be such that profits for a firm from region A supplying its product in region A or in region B are equal. This is exactly the case when the net price for supplying in the two regions is the same for this firm. Therefore, the equilibrium value $\xi^* = \xi(\tau)$ of ξ is endogenously determined as the unique solution to

$$p_A(\xi) = p_B(\xi,\tau)(1-\tau). \quad (2)$$

Note that under free trade we have $\tau = 0$ and $\xi^* = \xi(0)$ will be such that $p_A(\xi^*) = p_B(\xi^*) = \widehat{p}$. On the other hand, the autarkic market equilibrium emerges when τ is

[2] Alternatively, we could assume that a fixed tariff, independent of the price, has to be paid for each unit sold in region B by a firm from region A, or that a fixed cost (independent of the total quantity sold) is imposed on firms from A supplying in region B. The results from these alternative specifications are qualitatively similar to the ones we get in the current version of the paper.

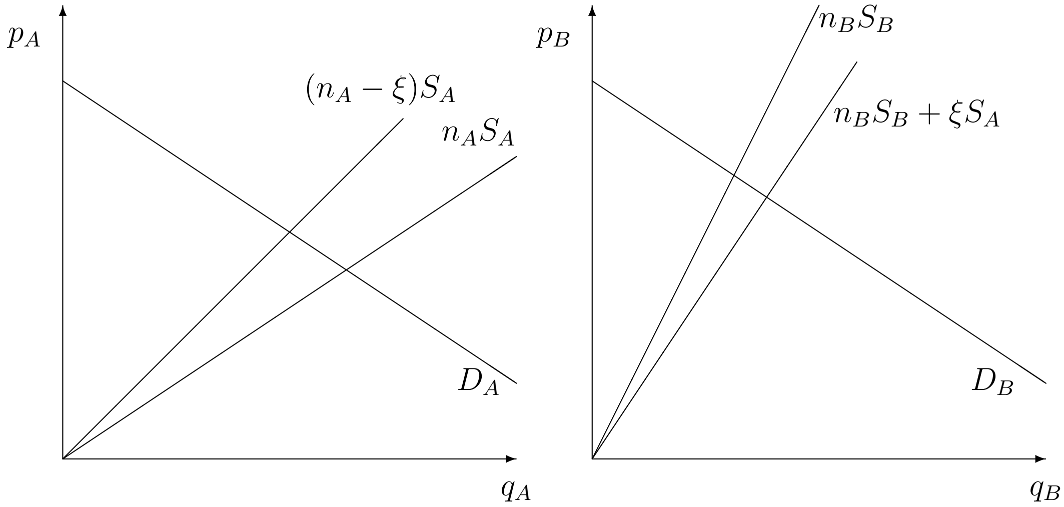

Figure 3: Market equilibrium when ξ firms from region A supply their product in region B.

prohibitively high and deters every firm from region A from supplying its product in region B. This is the case whenever τ is such that $p_A(0) \geq p_B(0,\tau)(1-\tau)$ (recall that $p_A(0)$ is the lowest possible equilibrium price in region A and $p_B(0,\tau)$ the highest possible equilibrium price in region B, given τ).

In the remainder of this subsection we will focus on the linear specification introduced before. In that case, using (1), equilibrium prices, for given values of ξ and τ, are

$$p_A(\xi) = \frac{a}{1+n_A-\xi} \text{ and } p_B(\xi,\tau) = \frac{b}{1+n_B+\xi(1-\tau)}.$$

Individual profits for a firm A active in region A (denoted by π_A) or active in region B (denoted by π_A^B) follow as

$$\pi_A(\xi) = \frac{1}{2}\left[p_A(\xi)\right]^2 \text{ and } \pi_A^B(\xi,\tau) = \frac{1}{2}\left[(1-\tau)\,p_B(\xi,\tau)\right]^2$$

Profits are therefore the same when prices (net of tariffs) in the regions are equal, that is, when condition (2) holds. From this condition we obtain

$$\begin{aligned} \xi^* &= \xi(\tau) = \frac{b(1-\tau)(1+n_A) - a(1+n_B)}{(1-\tau)(a+b)} \\ &= \frac{(1+n_A)(1+n_B)}{1-\tau}\frac{(1-\tau)p_B^a - p_A^a}{(1+n_A)p_A^a + (1+n_B)p_B^a}. \end{aligned} \tag{3}$$

Note that, as expected, $\xi(\tau)$ is decreasing in τ and it is positive as long as $(1-\tau)p_B^a > p_A^a$. Finally, not all firms from region A will supply their product in region B, that is $\xi(0) < n_A$, as long as $a(1+n_A+n_B) > b$.

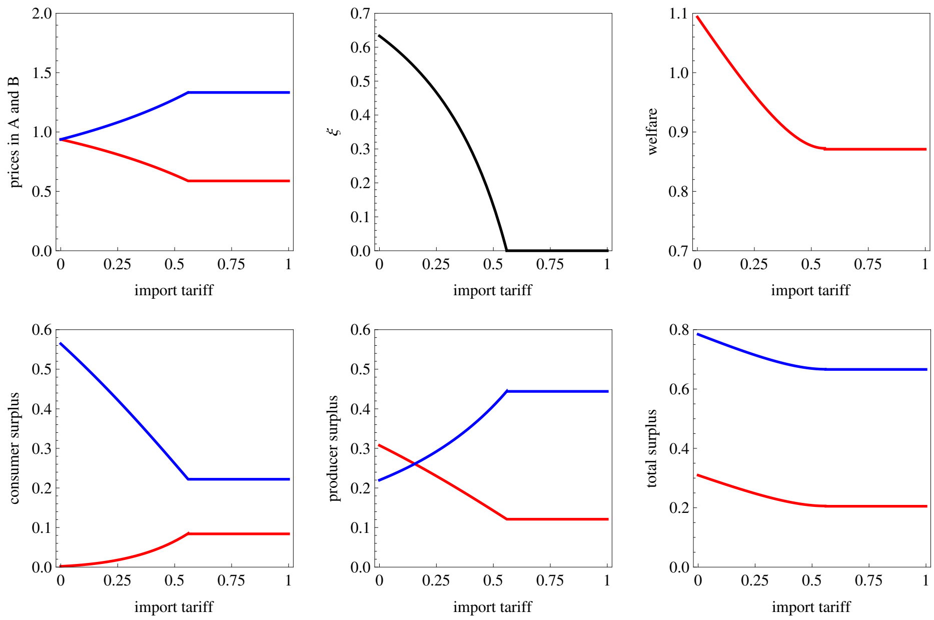

Figure 4: Evolution of prices in region A (red) and B (blue), number of firms from A entering market B and different measures for welfare as a function of τ ($a = 1, b = 2, n_A = 0.7$ and $n_B = 0.5$).

For a better understanding of these results, Figure 4 illustrates the evolution of steady-state prices in regions A and B as τ is increased from 0 to 1. As a baseline scenario, we rely on the following parameter setting: $a = 1, b = 2, n_A = 0.7, n_B = 0.5$. The panels indicate that for $\tau = 0$ prices in both regions coincide with the free trade equilibrium price. In turn, for import tariffs exceeding a threshold of about $\tau = 0.558$ tariffs will be so prohibitively high that no firm from region A will supply its product in region B. This is the autarky situation. The panels also reveal that consumers (producers) from region B (A) will profit from free trade, whereas consumers (producers) in country A (B) are better off if markets are in autarky. On an aggregate level, however, total welfare is highest under free trade.

3 Dynamic effects of import tariffs

In this section we broaden the static point of view of the last section by considering a dynamic framework in which producers from region A – depending on past profit opportunities – endogenously decide to supply their products in either region A or region B. In particular, we are interested in how such evolving market entry decisions affect both price dynamics and welfare.

3.1 Price dynamics

We assume that firms face a one-period production lag in producing the commodity and therefore have to predict the market clearing price one period in advance. Let

$p^e_{A,t}$ be the price that firms expect to occur in period t in region A. Similarly, let $p^e_{B,t}$ be the price expectation, for period t in region B. Since these expectations are determined in period $t-1$, they may involve all past prices up to $p_{A,t-1}$ and $p_{B,t-1}$.

A firm from region A supplying its products in region A will now supply $S_A\left(p^e_{A,t}\right)$ in period t and the supply of firms from region A and region B producing for region B are $S_A\left((1-\tau)\,p^e_{B,t}\right)$ and $S_B\left(p^e_{B,t}\right)$, respectively.

Expectations can be modelled in a variety of ways. As in the classical cobweb framework (see e.g. Ezekiel, 1938) firms form, for the moment, *naive expectations*, i.e.

$$p^e_{A,t} = p_{A,t-1} \text{ and } p^e_{B,t} = p_{B,t-1}.$$

As is well known, stability of the steady state then depends on the relative slopes of the demand and supply functions.[3] For example, when considering the autarkic benchmark the evolution of temporary market clearing prices under naive expectations is implicitly determined by

$$D_A\left(p_{A,t}\right) = n_A S_A\left(p_{A,t-1}\right) \text{ and } D_B\left(p_{B,t}\right) = n_B S_B\left(p_{B,t-1}\right).$$

Assuming invertible demand functions then yields

$$p_{A,t} = D_A^{-1}\left(n_A S_A\left(p_{A,t-1}\right)\right) \text{ and } p_{B,t} = D_B^{-1}\left(n_B S_B\left(p_{B,t-1}\right)\right),$$

and the market equilibria will be *locally stable* as long as $\left|D_i'\left(p_i^a\right)\right| > \left|n_i S_i'\left(p_i^a\right)\right|$ for $i = A, B$. For Figure 1 this means that the (inverse) demand function should be **flatter** than the (inverse) supply function. In the following, we assume that these *cobweb dynamics* under autarky are stable in each of the two markets.

Higher (equilibrium) profits in region B attract firms from region A. This increases the supply elasticity in region B. If this supply elasticity increases sufficiently this may now give rise to *unstable cobweb dynamics* in region B (see e.g. Dieci and Westerhoff, 2009). In particular, instability sets in whenever the following inequality holds

$$\left|n_B S_B'\left(p_B\left(\xi\right)\right) + \xi\left(1-\tau\right) S_A'\left(p_B\left(\xi\right)\left(1-\tau\right)\right)\right| > \left|D_B'\left(p_B\left(\xi\right)\right)\right|.$$

That is, because firms from region A supply their product in region B supply in region B increases, which flattens the (aggregate) inverse supply curve, see Figure 3. From now on we will assume that for the case of free trade ($\tau = 0$) the market equilibrium in region B is indeed unstable. This implies that there exists a critical value of ξ such that for larger values of ξ the dynamics are going to be unstable.

3.2 Entry decisions

How do firms from region A decide to supply their product in either region A or region B. We will assume that they base this decision upon past realized profits. In particular, denote by

$$\pi_{A,t} = p_{A,t} S_A\left(p_{A,t-1}\right) - c_A\left(S_A\left(p_{A,t-1}\right)\right)$$

[3]To check the robustness of our results we consider the case of adaptive expectations in Section 4.2. There we also briefly address the case of rational expectations.

profits earned in period t by firms from region A supplying their product in region A, and by

$$\pi^B_{A,t} = p_{B,t} S_A \left(p_{B,t-1}\left(1-\tau\right)\right) - c_A \left(S_A \left(p_{B,t-1}\left(1-\tau\right)\right)\right)$$

profits earned in period t by firms from region A supplying their product in region B. We posit that when $\pi^B_{A,t-1}$ is larger (smaller) than $\pi_{A,t-1}$, ξ goes up (down). We model the evolution of ξ by the following map

$$\xi_t = G\left(\pi^B_{A,t-1}, \pi_{A,t-1}, \xi_{t-1}\right). \tag{4}$$

where (4) satisfies the following properties:

- $0 \leq G\left(\pi^B_A, \pi_A, \xi\right) \leq n_A$;
- $G\left(\cdot\right)$ increases in π^B_A and ξ and decrease in π_A;
- $G\left(\pi, \pi, \xi\right) = \xi$.

In the remainder we will use the so-called *exponential replicator dynamics*

$$G\left(\pi^B_{A,t-1}, \pi_{A,t-1}, \xi_{t-1}\right) = n_A \times \frac{\xi_{t-1}\exp\left[\beta\left(\pi^B_{A,t-1}\right)\right]}{\xi_{t-1}\exp\left[\beta\pi^B_{A,t-1}\right] + \left(n_A - \xi_{t-1}\right)\exp\left[\beta\pi_{A,t-1}\right]},$$

where β is the *intensity of choice* which measures how sensitive firms from region A will react to differences in profits.[4]

3.3 Model dynamics and stability

Let us return to our specification with linear demand and supply curves. Under naive expectations the equilibrium equations (1) result in the following market clearing prices

$$p_{A,t} = a - \left(n_A - \xi_t\right) p_{A,t-1} \text{ and } p_{B,t} = b - \left(n_B + \left(1-\tau\right)\xi_t\right) p_{B,t-1}.$$

Obviously, the price dynamics in region B are unstable whenever $n_B + \left(1-\tau\right)\xi > 1$.

[4]Another model that is often used to describe evolutionary dynamics in economics is the discrete choice model (see, e.g. Brock and Hommes, 1997, and in a framework similar to ours, Dieci and Westerhoff, 2009, 2010). As the exponential replicator dynamics the discrete choice model is parameterized by an intensity of choice parameter (which is not the case for the standard replicator dynamics). We would like our evolutionary model to have the property that at the steady state the number of firms from region A that supply their product in region B is such that profits for these firms are the same in both regions. However, the discrete choice model has the unattractive property that $G\left(\pi, \pi, \xi\right) = \frac{1}{2}$, which is typically unequal to ξ, implying that at the steady state there will still be profit opportunities for firms from region A. The exponential replicator dynamics, in contrast, ensures that $G\left(\pi, \pi, \xi\right) = \xi$. Note that the replicator dynamics originates from evolutionary biology (see, e.g. Hofbauer and Sigmund 1988 for an introduction). For the exponential replicator dynamics, see Hofbauer and Weibull (1996).

The full dynamic model can be summarized by

$$\begin{aligned} p_{A,t} &= a - (n_A - \xi_t)\, p_{A,t-1}, \\ p_{B,t} &= b - (n_B + \xi_t (1-\tau))\, p_{B,t-1}, \\ \xi_t &= \frac{n_A \exp\left[\beta \pi^B_{A,t-1}\right]}{\xi_{t-1} \exp\left[\beta \pi^B_{A,t-1}\right] + (n_A - \xi_{t-1}) \exp\left[\beta \pi_{A,t-1}\right]}, \end{aligned} \tag{5}$$

where profits are determined as

$$\pi_{A,t} = \left(p_{A,t} - \frac{1}{2} p_{A,t-1}\right) p_{A,t-1} \text{ and } \pi^B_{A,t} = (1-\tau)^2 \left(p_{B,t} - \frac{1}{2} p_{B,t-1}\right) p_{B,t-1}.$$

Now we consider the steady state equilibrium of dynamic system (5). First note that if $(1-\tau)\, p^a_B \leq p^a_A$, or equivalently, if $\tau \geq \overline{\tau} \equiv \frac{b(1+n_A) - a(1+n_B)}{b(1+n_A)} \in (0,1)$ no firm from region A has an incentive to suppply in region B, because the import tariffs are too high. The steady state equilibrium of (5) then coincides with the autarkic steady state: $(p^*_A, p^*_B, \xi^*) = (p^a_A, p^a_B, 0)$. In the more interesting case with $\tau < \overline{\tau}$, and provided that $a(1 + n_A + n_B) \geq b$, the steady state equilibrium of (5) is given by[5]

$$\begin{aligned} & (p^*_A, p^*_B, \xi^*) \\ = & \left((1-\tau)\, p^*_B, \frac{a+b}{(1-\tau)(1+n_A) + (1+n_B)}, \frac{b(1-\tau)(1+n_A) - a(1+n_B)}{(1-\tau)(a+b)}\right). \end{aligned} \tag{6}$$

In general, (local) stability of this steady state crucially depends on the interplay between parameters a, b, n_A, n_B, τ and β. In particular, there are two roads to instability. The first of these emerges naturally and is caused by the interaction between the two markets, as in Dieci and Westerhoff (2009, 2010). If import tariffs are low at the steady state equilibrium many firms from region A are attracted to region B. This increases supply elasticity so much that price dynamics in that region become unstable. This finding can be summarized as follows.

Lemma 2 *Assume $n_A < 1$, $n_B < 1$ and $n_A + n_B > \max\left\{\frac{b-a}{a}, \frac{2a}{b}\right\}$ and let*

$$\tau^* = \frac{1}{1+n_A}\left(n_A + n_B - \frac{2a}{b}\right). \tag{7}$$

We have $0 < \tau^* < \overline{\tau}$. If $\tau < \tau^*$ the steady state (6) of the model (5) is unstable for any $\beta > 0$.

Proof. First note that $n_A + n_B > \frac{b-a}{a}$ implies that $\xi(\tau) \leq \xi(0) < n_A$ for all τ. Now, at the steady state equilibrium (6), the price dynamics in region B are unstable when $\phi(\tau) = n_B + (1-\tau)\,\xi(\tau) > 1$. Using (6) and $n_A + n_B > \frac{2a}{b}$ it is straightforward to verify that $\phi(\tau)$ is decreasing in τ, with $\phi(\overline{\tau}) = n_B < 1$ and $\phi(0) = n_B + \xi(0) > 1$.

[5] The condition $a(1 + n_A + n_B) \geq b$ ensures that $\xi(0) \leq \xi(\tau) \leq n_A$ for all τ. If this condition does not hold, ξ^* will be equal to n_A for small values of τ. This would correspond to the extreme case that all firms from region A supply their product to region B, leaving consumers from region A unable to buy the product.

The unique solution to $\phi(\tau) = 1$ is given by τ^* given in (7). Therefore, for any $\tau \in [0, \tau^*)$ price dynamics in region B are going to be unstable at the steady state equilibrium, independent of the value of β, and therefore the steady state equilibrium will be unstable. ■

But instability can also set in if $n_B + (1 - \tau)\,\xi^* < 1$, that is, if in equilibrium the number of firms supplying in region B is not destabilizing by itself. This second road to instability corresponds to the more familiar 'overshooting' phenomenon. If β, the sensitivity with which firms from region A respond to profit differences, is high, a small difference in profits may cause too many firms moving to region B. This depresses profits in region B and drives many firms from region A back to supplying their product in their home market. The next lemma describes this type of instability.

Lemma 3 *Let $n_A < 1$, $n_B < 1$ and $n_A + n_B > \max\left\{\frac{b-a}{a}, \frac{2a}{b}\right\}$. In addition, let $\tau \geq \tau^*$. Then there exists a $\beta^*(\tau) > 0$ for which the dynamics will be unstable for any $\beta > \beta^*$. Moreover, β exceeding β^* is a necessary condition for a flip bifurcation.*

Proof. The lemma follows from a detailed stability analysis, which is presented in the appendix. ■

From Lemmas 2 and 3 we obtain stability curves which separate stable and unstable parameter combinations. For example, for our baseline parameter setting with $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$ we obtain the steady state equilibrium

$$(p_A^*, p_B^*, \xi^*) = \left(\frac{30\,(1-\tau)}{32 - 17\tau}, \frac{30}{32 - 17\tau}, \frac{19 - 34\tau}{30\,(1-\tau)}\right),$$

provided that $\tau \leq \overline{\tau} = \frac{19}{34} \approx 0.559$. For this parameter setting we have the following critical values for local stability:

$$\tau^* = \frac{2}{17} \approx 0.118 \text{ and } \beta^* = \frac{140\,(10\xi^* + 3)\,(1 - 2\xi^*\,(1-\tau))}{20\xi^*\,(p_B^*)^2\,(1-\tau)^2\,(8 - 3\tau)\,(7 - 10\xi^*)}.$$

Figure 5 illustrates the different stability and instability regions for this particular numerical example. In this plot the white area shows unstable parameter combinations of τ and β, whereas stable parameter combinations are given in gray. Moreover, the dashed lines indicate the critical values τ^* and β^*. Note that, as τ approaches τ^* from above, a smaller value of β will already destabilize the dynamics. In a sense, therefore, the two roads to instability interact.

4 The trade-off between allocative efficiency and stability: optimal import tariffs

In the previous two sections we have seen two effects of a decrease in import tariffs. First, *at the steady state*, allocative efficiency is higher and total surplus increases

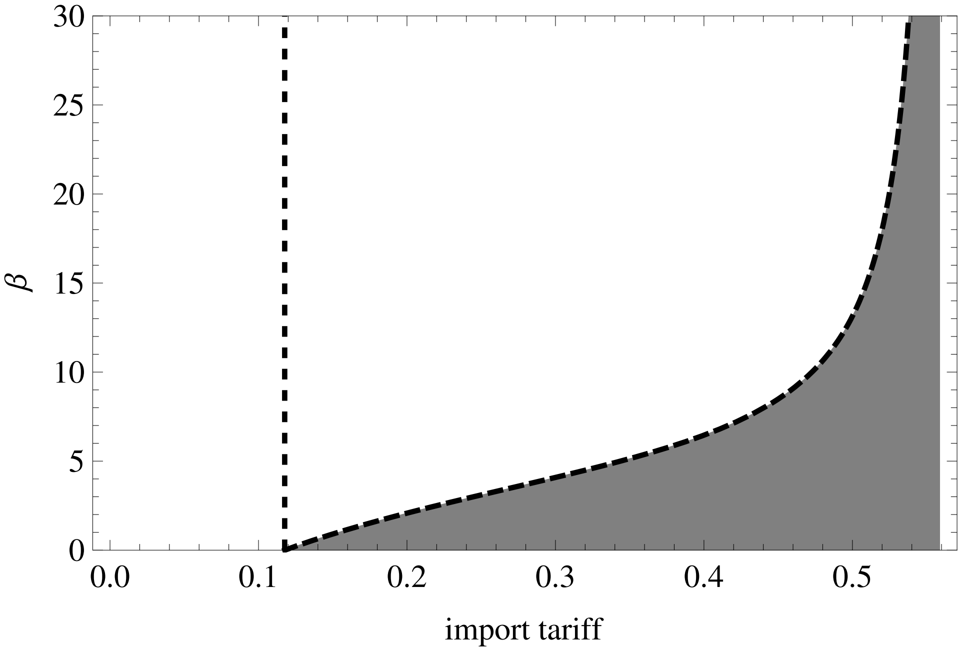

Figure 5: Stability and instability regions in parameter space. Stable (unstable) combinations of import tariff τ and parameter β are given in gray (white). The critical values τ^* and β^* are indicated by the dashed lines. The remaining parameters are the same as in our basic parameter setting.

in both regions. Second, a decrease in import tariffs may also induce instability, leading to volatility in prices and outcomes. In the following we analyze the allocative consequences of such dynamics and try to answer the question whether there is an optimal level of import tariffs.

4.1 Optimal import tariffs

What follows are a number of simulations for our baseline parameter setting with $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$. This particular parameter setting satisfies the assumptions of Lemmas 2 and 3, implying that dynamics are unstable under free trade and stable for autarkic markets.[6] Moreover, we have $\overline{\tau} = \frac{19}{34} \approx 0.559$, $\tau^* = \frac{2}{17} \approx 0.118$ and $\xi(0) = \frac{19}{30} \approx 0.633$. We want to gain insight in the distributional effects of decreasing τ from 1 (autarky) to 0 (free trade) by considering different measures of welfare. First, we are interested in changes in *consumer surplus* CS_A, CS_B and changes in *producer surplus* (i.e. aggregate firm profits) PS_A and PS_B in both regions. In addition, we want to understand the change in *total surplus* (per region), $TS_A = CS_A + PS_A$ and $TS_B = CS_B + PS_B$, and *aggregate total surplus* $TS = TS_A + TS_B$.

We begin our numerical investigation by briefly exploring the model's dynamics in the time domain. For this reason we extend the above baseline parameter setting by choosing $\tau = 0.1$ and $\beta = 10$. According to Lemma 2 the dynamics will then

[6] The results are robust with respect to changes in the parameter values.

be unstable since $\tau < \tau^*$. As revealed by Figure 6, which shows the evolution of prices in regions A and B and the number of firms from A being active in B, prices neither explode nor converge but fluctuate around their equilibrium values of about $p_A^* \approx 0.89$ and $p_B^* \approx 0.99$ in an irregular and erratic manner. These dynamics are created endogenously within our model by an evolving number of firms from region A which seek to maximize profits by supplying their products in region B. To be precise, the dynamics unfold as follows. When prices in region B, and hence profit opportunities, are high, firms from region A are encouraged to sell their goods in region B which, in turn, induces prices in region B to go down and prices in region A to go up. Higher prices in region A and lower prices in region B, however, reduce the incentive for firms from region A to enter market B, which causes prices in A (B) to decrease (increase).

But how do these fluctuations and different import tariffs affect welfare? To answer this question, Figures 7 to 9 show the corresponding bifurcation diagrams of prices, the number of exporting firms and some characteristic welfare measures for different values of the intensity of choice β. Clearly, both markets are in autarky if import tariffs exceed the threshold of $\overline{\tau} \approx 0.559$, making exporting to region B prohibitively expensive for firms from region A. This holds for any value of β. In the absence of trade barriers, i.e. for $\tau = 0$, firms from A repeatedly enter market B to sell their products. For high values of β there are even periods where almost all firms from region A enter market B. Surprisingly, however, the diagrams show that in all three scenarios neither free trade nor autarky is welfare optimizing. Instead, welfare, as measured by the time average of aggregate total surplus, peaks at an intermediate import tariff. This optimal import tariff turns out to correspond exactly to the critical stability threshold of τ, which is going to depend upon the value of β. That is, for values of τ above (below) this threshold the steady state equilibrium will be stable (unstable).

This deviation from the welfare effects illustrated in Figure 4 contradicts conventional economic wisdom and can be explained as follows. Consumers from region B prefer free trade: they benefit from decreased prices due to lower tariffs, even if these prices are volatile. Exactly the opposite holds for firms from region B, who prefer autarky: if trade barriers decrease they receive lower prices and this is detrimental to their profits (even if these prices are stable). Remarkably, firms from A do not benefit unambiguously from lower import tariffs. Although these firms initially gain from a decrease in import tariffs (and hence higher prices and profits), their producer surplus goes down again as prices become volatile. Surplus for producers from region A therefore peaks at the lowest possible value of τ for which price dynamics are still stable. Maybe equally interesting is the observation that, although at the steady state consumer surplus of consumers in region A goes down because of higher prices, consumer surplus has a tendency to go *up* if prices become volatile. This may be explained by the fact that consumer surplus is a convex function of the consumed quantity.

The net result of these different welfare effects is that volatility decreases aggregate total surplus.[7] Accordingly, there exists an optimal non-zero level of τ. To

[7]Note that in our welfare analysis we abstract from the risk attitude of consumers and producers,

understand better this welfare-enhancing effect of stable prices, recall that producers form naive expectations and may thus make two types of mistakes when the dynamics is unstable. First, producers from region A may have chosen the wrong region to supply their product and, second, given the region they chose they make incorrect price predictions and therefore suboptimal production decisions. Both effects, obviously have a negative impact on producer surplus (and hence on average welfare), albeit the latter effect becomes less important as long as price dynamics are relatively stable.

So far, we have not incorporated the revenues from import tariffs into the welfare analysis. In Figure 10 we consider the case where revenues from import tariffs are redistributed among consumers and producers from region B. Total surplus in region B at time t is now given by $TS_{B,t} = CS_{B,t} + PS_{B,t} + R_t$, where R_t corresponds to revenues from the import tariffs. These are equal to the number of firms from region A supplying in region B (ξ_t) times the tariff that they pay per unit of sold commodity ($\tau p_{B,t}$) times the number of units they sell ($S_A\left((1-\tau)\,p_{B,t}\right)$), which gives $R_t = \xi_t \tau p_{B,t} S_A\left((1-\tau)\,p_{B,t}\right) = \xi_t \tau (1-\tau) p_{B,t}^2$. The diagrams in Figure 10 reveal that such a redistribution does not affect qualitatively the aforementioned results.

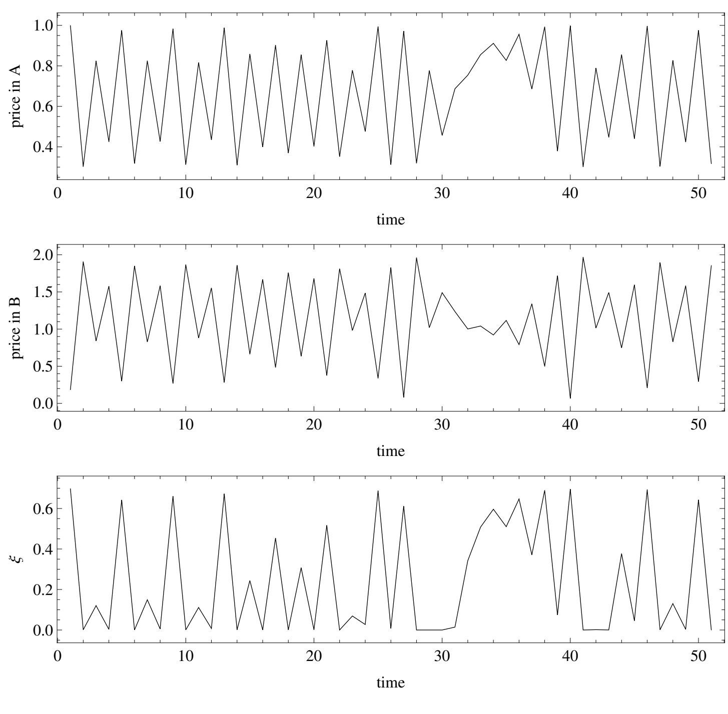

Figure 6: Evolution of prices in region A (upper panel) and in region B (middle panel) and the number of firms from region A supplying their product in region B (ξ_t, lower panel). Parameters: $a = 1$, $b = 2$, $n_A = 0.7$, $n_B = 0.5$, $\tau = 0.1$ and $\beta = 10$.

which may be relevant when prices are volatile. Also, we use unweighted averages to compute the welfare measures and therefore do not discount outcomes that lie in the more distant past.

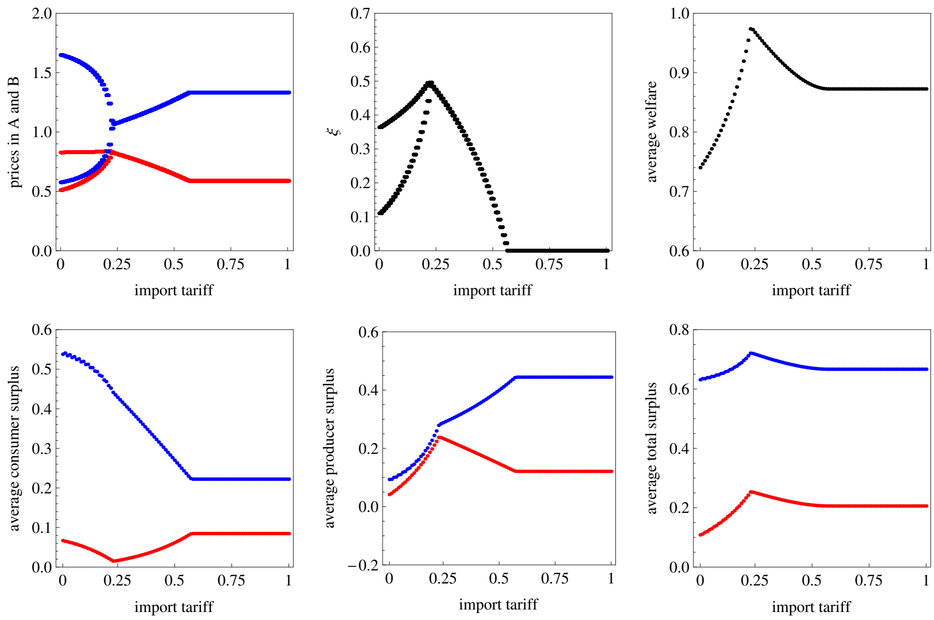

Figure 7: Evolution of prices (upper left panel), number of exporting firms (upper middle panel), aggregate total surplus (averaged over time, upper right panel), average consumer surplus (lower left panel), average producer surplus (lower middle panel) and average total surplus per region (lower left panel) for $\beta = 2.5$ as a function of τ (other parameters: $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$). Region A (B) is given by the red (blue) line. Optimal import tariff: $\tau \approx 0.22$.

4.2 Optimal import tariffs and adaptive expectations: a robustness check

Section 4 has established that there may be *welfare-optimizing* trade barriers for market B, i.e. neither free trade nor autarky may be optimal for average welfare. Moreover, a redistribution of import tariff revenues among consumers and producers from region B does not change this insight.

However, these results have been obtained for the case of naive expectations. To check their robustness, we now allow firms to form *adaptive expectations* (see e.g. Nerlove, 1958), i.e.

$$p^e_{A,t} = p^e_{A,t-1} + \delta(p_{A,t-1} - p^e_{A,t-1}) \text{ and } p^e_{B,t} = p^e_{B,t-1} + \delta(p_{B,t-1} - p^e_{A,t-1}).$$

Parameter δ is limited to values between 0 and 1 and may be regarded as the coefficient of revision. It defines how strongly producers will revise their expectations due to changes in previous forecasting errors. For $\delta = 0$ expectations are autonomous, i.e. completely independent from previously realized prices. In turn, for $\delta = 1$ producers will employ naive expectations. Hence, the higher the parameter δ the more closely adaptive expectations will resemble naive expectations.

Figure 11 illustrates the changes in average welfare as both parameters δ and τ are varied as indicated on the axes. In these contour plots lighter shades of blue indicate higher average welfare. Each panel is depicted for a different value of parameter

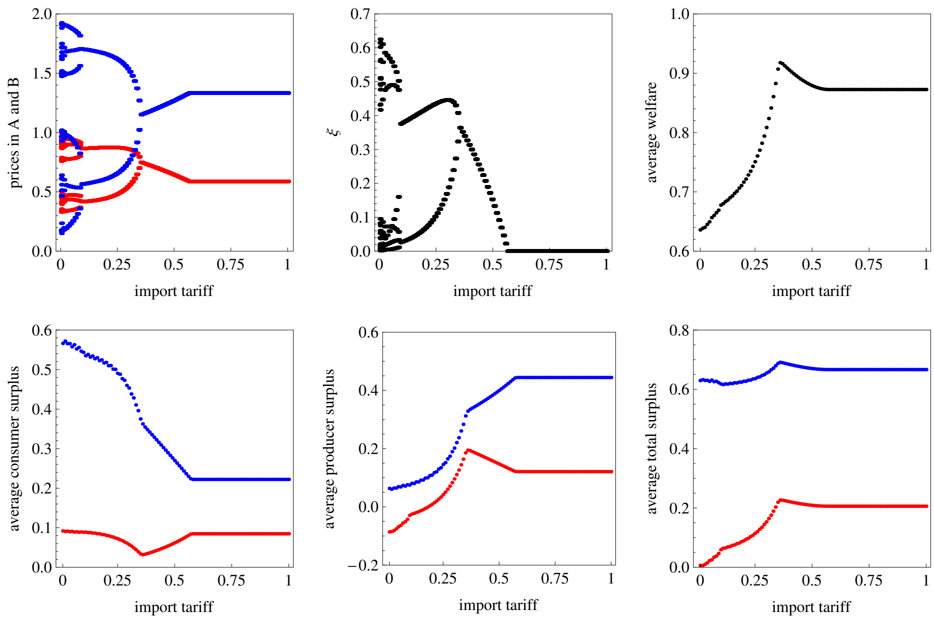

Figure 8: Evolution of prices (upper left panel), number of exporting firms (upper middle panel), aggregate total surplus (averaged over time, upper right panel), average consumer surplus (lower left panel), average producer surplus (lower middle panel) and average total surplus per region (lower left panel) for $\beta = 5$ as a function of τ (other parameters: $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$). Region A (B) is given by the red (blue) line. Optimal import tariff: $\tau \approx 0.344$

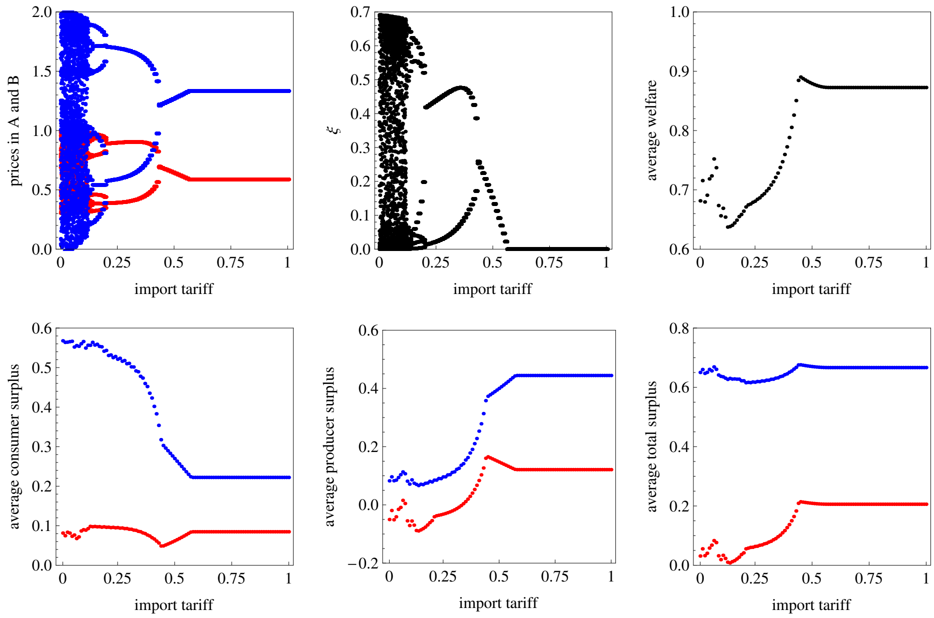

Figure 9: Evolution of prices (upper left panel), number of exporting firms (upper middle panel), aggregate total surplus (averaged over time, upper right panel), average consumer surplus (lower left panel), average producer surplus (lower middle panel) and average total surplus per region (lower left panel) for $\beta = 7.5$ as a function of τ (other parameters: $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$). Region A (B) is given by the red (blue) line. Optimal import tariff: $\tau \approx 0.43$

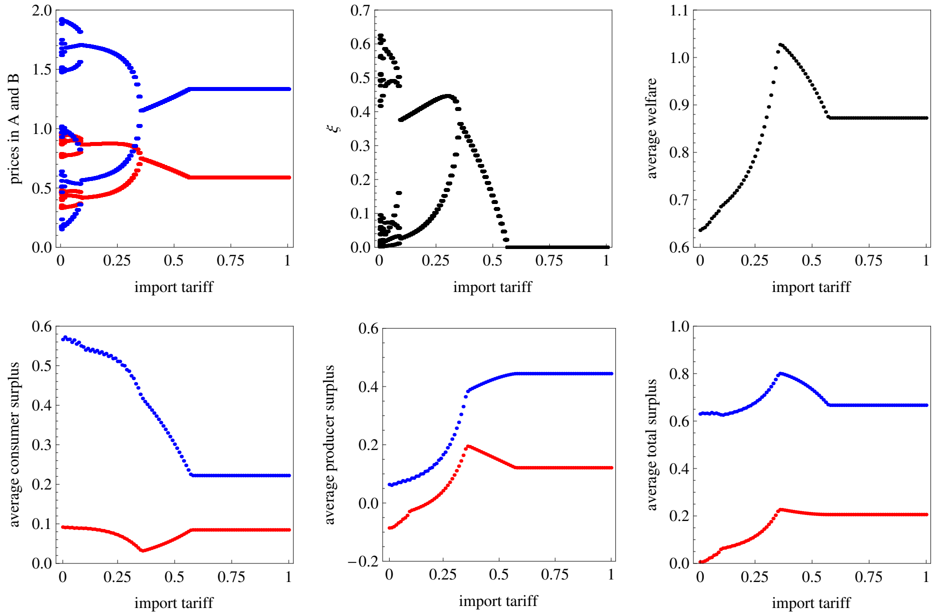

Figure 10: Evolution of prices (upper left panel), number of exporting firms (upper middle panel), aggregate total surplus (averaged over time, upper right panel), average consumer surplus (lower left panel), average producer surplus (lower middle panel) and average total surplus per region (lower left panel) for $\beta = 7.5$ as a function of τ (other parameters: $a = 1$, $b = 2$, $n_A = 0.7$ and $n_B = 0.5$). Region A (B) is given by the red (blue) line. Revenues from the import tariffs are redistributed to consumers and producers from region B. Optimal import tariff: $\tau \approx 0.43$.

β and the thick black lines separate stable from unstable parameter combinations, i.e. all combinations of δ and τ below and to the right of these lines lead to stable outcomes. The panels reveal that for low values of β (a low sensitivity of choice) only stable outcomes are welfare maximizing. However, the higher β the more likely unstable combinations of τ and δ will lead to a welfare maximizing outcome. This particularly holds true for low values of δ, i.e. the further (adaptive) expectations deviate from naive expectations. For instance, for $\beta = 2.5$ and $\beta = 5$ all welfare-maximizing combinations lie exactly on or below the black stability curve. This means that for high values of δ, i.e. for adaptive expectations not too distant from naive expectations trade barriers maximize average welfare. For low values of δ, in turn, free trade is optimal. For $\beta = 10$ and δ low, free trade is still the optimal solution, albeit such a parameter combination leads to unstable outcomes in prices on both markets.[8] Moreover, Figure 12 suggests that redistributing revenues from import tariffs among producers and consumers in region B does not affect these results much: for high values of δ a redistribution of revenues merely decreases the level of the welfare-optimizing tariff in all scenarios.

5 Endogenous import tariffs

So far we approached import tariffs from a *normative* perspective: we investigated which level of import tariffs is optimal from the point of view of aggregate welfare. In this section we will take a *descriptive* perspective. In particular, we recognize that import tariffs are determined in the political arena, through elections, political participation, interest group behavior, lobbying or campaign contributions.[9]

From the previous sections it is clear that firms (consumers) in B benefit from a increase (decrease) in the import tariff τ. Now let us start with a very simple and highly stylized reduced form description of the outcome of the political process. Let τ_P (τ_C) be the preferred tariff level of the producers (consumers) in region B. It follows that $\tau_P = \overline{\tau}$ and $\tau_C = 0$.

The outcome of the political process in region B may then be that the actual import tariff equals

$$\tau = \alpha\tau_P + (1-\alpha)\,\tau_C = \alpha\overline{\tau},$$

where $\alpha \in [0, 1]$ measures the relative political influence of the producers in region B, which depends on political institutions, bargaining power, etc. From the previous analysis we know that an increase in α decreases allocative efficiency but enhances stability. Where the economy will end up and whether dynamics will be stable then is determined by the relative political influence of the two special interest groups.

[8] Simulations with rational expectations yield similar results. Depending on parameters either a (moderate) level of an import tariff or free trade is welfare maximizing. A parameter combination for which there exists an optimal positive import tariff, for instance, is given by $a = 1$, $b = 1.1$, $n_A = 0.75$, $n_B = 0.35$ and $\beta = 50$.

[9] There is a substantial literature on the political economy of trade barriers, see e.g. Grossman and Helpman (1994, 2001).

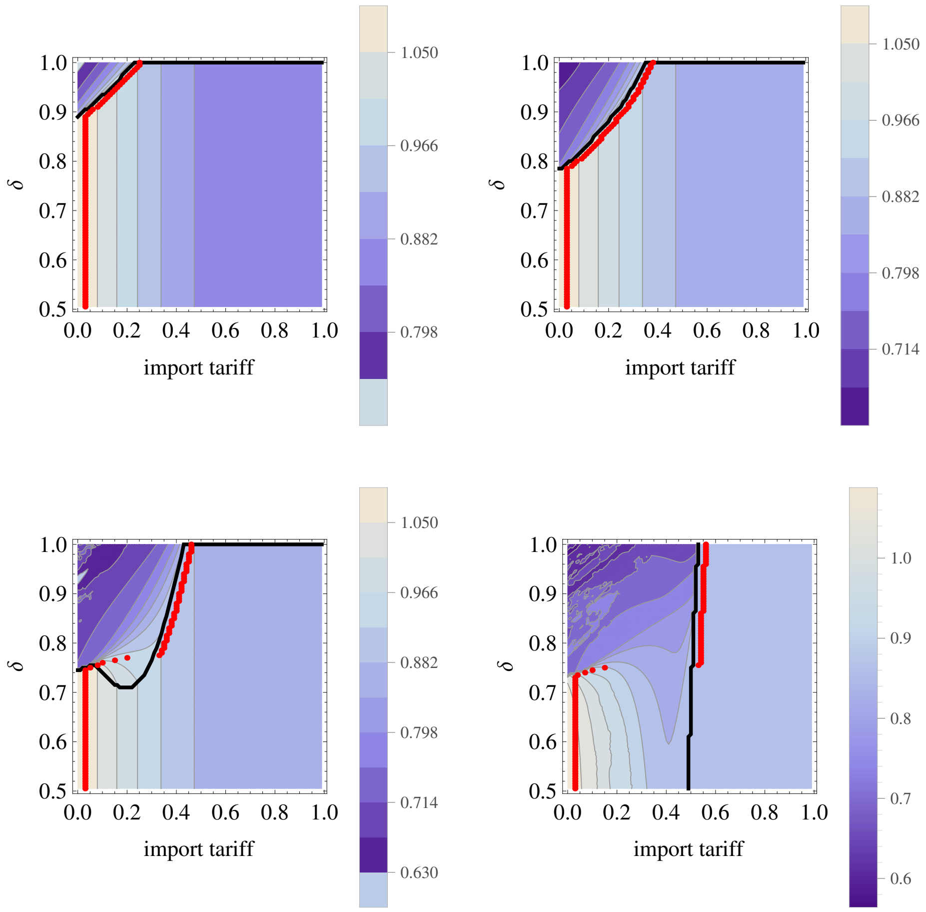

Figure 11: Evolution of average welfare as parameters δ and τ are varied as shown on the axes. Lighter colors in the contour plots indicate higher average welfare. The thick black lines separate stable and unstable combinations of δ and τ. The minimal welfare-improving import tariff for each δ is given by the dotted red line. Each panel is depicted for a different value of β (from top left to bottom right: $\beta = 2.5$, $\beta = 5$, $\beta = 7.5$ and $\beta = 20$).

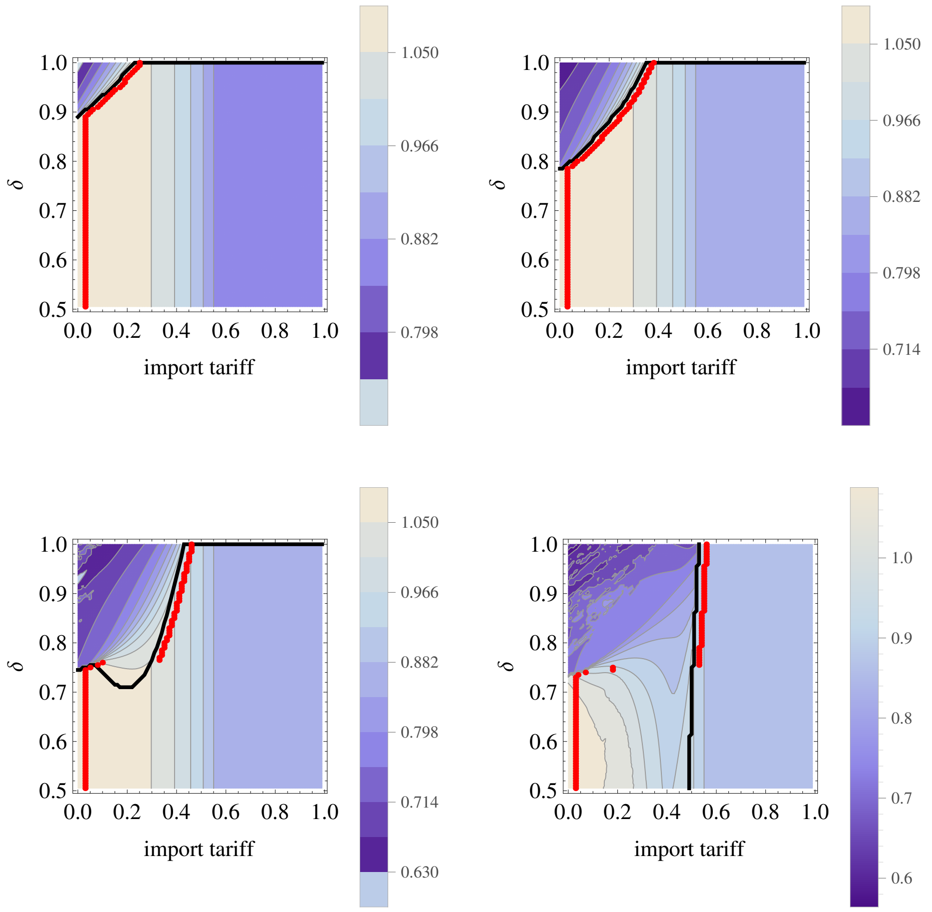

Figure 12: Evolution of average welfare as parameters δ and τ are varied as shown on the axes and with revenues from import tariffs distributed among producers and consumers in region B.

As a next step we allow for the possibility that the outcome of the political process may depend on economic conditions. In particular, there is empirical evidence of so-called "negative voting", i.e. people have a higher tendency to become politically active when they are more dissatisfied with the *status quo*.[10] Sadiraj et al. (2005) model participation in special interest groups on the basis of this idea and calibrate their model on evidence from laboratory experiments with human subjects. Here we consider a similar approach for the determination of import tariffs τ.

Consider the following specification

$$\begin{aligned}\tau_t &= \alpha_t \tau_P + (1-\alpha_t)\,\tau_C = \alpha_t \overline{\tau} \\ &= \frac{\exp\left[\phi_P\left(R_P - V_{P,t-1}\right)\right]}{\exp\left[\phi_P\left(R_P - V_{P,t-1}\right)\right] + \exp\left[\phi_C\left(R_C - V_{C,t-1}\right)\right]} \times \overline{\tau},\end{aligned}$$

where R_P and R_C are *reference points / aspiration levels* and $V_{P,t-1}$ and $V_{C,t-1}$ realized 'payoffs' (representing either firm profits or consumer surplus).

For the reference points we take $R_P = PS_{B,\tau=\overline{\tau}}$ and $R_C = CS_{B,\tau=0}$. That is, the reference points of both interest groups correspond to their preferred outcomes: firms aspire to the profits they earn in the autarkic steady state equilibrium, whereas consumers aspire to the consumer surplus (i.e., price and consumption levels) they get in the free trade steady state equilibrium. Realized payoffs (with $\mu \in [0,1]$) are given by

$$V_{P,t} = \mu PS_{B,t} + (1-\mu)\,V_{P,t-1} \text{ and } V_{C,t} = \mu CS_{B,t} + (1-\mu)\,V_{C,t-1}.$$

The reasoning behind these equations is quite straightforward. Satisfaction of consumers and producers with the political status quo (i.e., the current import tariff) depends on realized past profits. The more the realized producer (consumer) surplus deviates from the aspired level, the more strongly firms (consumers) will be dissatisfied with the status quo and lobby for a higher (lower) tariff. Moreover, the weight producers and consumers give to past realized profits decreases exponentially over time.

Figure 13 shows a typical simulation run for our model with endogenous import tariffs. As parameters for this simulation run we choose: $a = 1$, $b = 2$, $n_A = 0.7$, $n_B = 0.5$, $\beta = 5$, $\mu = 0.1$, $\phi_P = 1$ and $\phi_C = 20$. With these parameters the aspiration levels of consumers and producers approximately result as

$$R_P \approx 0.44 \text{ and } R_C \approx 0.56.$$

Since import tariffs are typically not adjusted every period the plots depict the situation where import tariffs are adjusted only every 16^{th} period. In other words, we assume that a quarter of a year corresponds to one period and that import tariffs are adjusted every four years, i.e. once in the typical political life cycle of a government. The plots reveal that outcomes on both markets fluctuate irregularly. That is to say, prices and hence realized profits in both markets constantly change over time.

[10] See e.g. Kernell (1977), Lau (1982) and Javeline (2003). For a further discussion see Sadiraj et al. (2010).

Also the endogenously determined import tariff shifts between destabilizing low and stabilizing high values. The mechanism that drives these dynamics is the following. Suppose we start out in a situation with relatively high import tariffs, i.e. a (stable) situation of autarky. Since realized consumer surplus is far below the aspired level, consumers will be unhappy with the status quo and start lobbying for a decrease in import tariffs. Lower import tariffs, however, will destabilize the dynamics and, hence, lead to a decrease (increase) in producer (consumer) surplus in region B. As a consequence, producers will become more politically active and demand higher tariffs. The subsequent increase in tariffs, in turn, causes realized profits of consumers to fall again such that the pattern repeats itself, yet in an intricate manner

Since in general only the firms benefit from (higher) trade barriers the policy makers in region B might have good reason to compensate consumers for their losses in welfare which occur due to higher import tariffs.[11] For this reason we want to study the welfare and price effects of such a redistribution of import revenues among consumers in region B. Accordingly, adjusted surplus and realized payoffs of consumers will now be given by

$$CS^R_{B,t} = \frac{1}{2}(b - p_{B,t})^2 + \xi_t \tau_t (1 - \tau_t) p^2_{B,t} \text{ and } V_{C,t} = \mu CS^R_{B,t} + (1 - \mu)\, V_{C,t-1}.$$

Figure 14 depicts a simulation run with these adjusted consumers' payoffs and for the above-given parameters.[12] At first sight the plots suggest that our results are not affected very much. Although the dynamics becomes more regular, outcomes on both markets still fluctuate. However, the truly revealing changes are hidden in the data. Taking a closer look at some statistical indicators shows that the average import tariff has increased from $\tau = 0.20$ in the scenario without redistribution to $\tau = 0.24$ in the scenario with redistribution. That is, on average consumers in region B are now more willing to accept higher import tariffs. Accordingly, price fluctuations in both regions also become more stable. Variance in prices goes down from 0.23 to 0.18 in market B and from 0.038 to 0.031 in market A. On the welfare side, the effects of a redistribution among consumers are as follows. In the scenario with redistribution of revenues both consumers and producers in region B profit from higher import tariffs. Surprisingly, this also holds for producers in region A. Although higher import tariffs clearly have a negative impact on their surplus, on average these producers benefit from the more stable prices while consumers from region A slightly lose. On an aggregate level, however, total surplus in both regions, and accordingly total average welfare increases.[13] Remarkably, correcting for the averagely paid revenues does not

[11] Such a compensation scheme might also come out of stabilization motives: the introduction of an import tariff may stabilize an otherwise unstable market and the policy makers might be inclined to promote compensation in exchange for consumers' political consent of such a trade barrier.

[12] Interestingly, there are coexisting attractors. Besides the depicted chaotic motion the dynamics may also converge to a period two cycle.

[13] To be precise, the statistical indicators change as follows. Average CS_A: 0.07 vs. 0.06, average PS_A: 0.04 vs. 0.075, average CS_B: 0.49 vs. 0.52, average PS_B: 0.15 vs. 0.19 and averagely redistributed revenues: 0.05.

change these results. Put differently, in our scenarios a redistribution of import revenues among consumers in region B will still be welfare-improving even if the government decides to collect the average amount of these revenues through other taxation channels right away later on.

6 Concluding remarks

In this paper we have investigated the trade off between allocative efficiency and stability that arises when a decrease in barriers to entry results in unstable cobweb dynamics. We have shown that there exist scenarios where aggregate welfare is best served by a positive import tariff. Moreover, this result is quite robust.

In addition, by explicitly considering the political economy of the determination of import tariffs we identified an additional source of instability. Special interest groups may lobby for a change in import tariffs that is beneficial to them, but which does not necessarily promote stability. This is particularly relevant if special interest groups are more likely to organize when its members are frustrated about the current economic status quo.

There exist other arguments in favor of barriers to trade in the literature on trading policies. The government may want to use barriers to trade to protect a specific industry, for example, to give a manufacturing industry in a developing country time to start up, or to appropriate the externalities from knowledge spillovers in high-technology industries in developed countries. Barriers to entry may also be optimal if competition in the protected industry is imperfect (see Brander and Spencer, 1985). For as far as we know we are the first to make the explicit argument that a decrease in import tariffs may lead to volatility and that therefore an optimal level of import tariffs exists.

We have used a very stylized model to make our argument. A number of interesting extensions are possible and we finally mention a few of them here. So far, firms rely on a particular prediction rule to forecast prices. Brock and Hommes (1997) show that endogenous cobweb dynamics may arise if firms endogenously switch between naive and costly rational expectations. Other types of nonlinearities, such as nonlinear demand and supply functions (Chiarella 1988, Day 1994, Hommes 1998) may also contribute to endogenous dynamics and thus affect welfare. A particular, yet quite natural nonlinearity may arise if one considers capacity constraints, as is, for instance, done in the discontinuous cobweb model of Kubin and Gardini (2013). As worked out by Avrutin et al. (2014), discontinuous maps may give rise to intriguing dynamic phenomena. Moreover, it might be interesting to relax the assumption that commodities in the two regions are homogeneous by allowing for some imperfect substitutability between these products. In such a framework, one may then take into account that the two regions are also connected from the demand side, as, e.g. in Currie and Kubin (1995) and Hommes and van Eekelen (1996). Of course, one may also try to embed our model into a general equilibrium setting and check the resulting welfare consequences. Another promising extension might be to add exogenous noise to the model and see how the market participants then cope with the dynamics, as is, for instance, done in Hommes and Rosser (2001). Dieci and Westerhoff (2010) find that price volatility may sharply increase due to *transient* dynamics as the steady state – in the presence of noise – approaches its stability frontier. Optimal trade barriers might turn out to be even higher, although this claim has to be investigated in more detail.

However, we conjecture that our main results remain valid in these more rich economic environments. Over the years, globalization has led to a system of highly nonlinearly connected markets which are prone to instability and complex endogenous dynamics, an outcome which may have negative welfare effects. Our analysis suggests that trade barriers, e.g. in the form of import tariffs, may be considered as an instrument to counter market instabilities.

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Appendix

A Proof of Lemma 1

Let $\Gamma(p) = (D_A(p) + D_B(p)) - (n_A S_A(p) + n_B S_B(p))$ denote aggregate excess demand at common price p. Note that $\Gamma(p)$ is downward-sloping in p and has a unique zero in $p = \widehat{p}$. We know that $\Gamma(p_A^a) = D_B(p_A^a) - n_B S_B(p_A^a) > 0$, since $p_A^a < p_B^a$. Therefore $\widehat{p} > p_A^a$. Moreover $\Gamma(p_B^a) = D_A(p_B^a) - n_B S_A(p_B^a) < 0$, since $p_B^a > p_A^a$ and therefore $\widehat{p} < p_B^a$.

Next, let total surplus in market $i = A, B$, TS_i, be defined as $TS_i = CS_i + PS_i$, where $CS_i = \int_0^{q_i} P_i^D(q)\, dq - p_i q_i$ and $PS_i = p_i q_i - \int_0^{q_i} P_i^S(q)\, dq$, in which P_i^D (P_i^S) refers to the inverse (aggregate) demand (supply) function in region i. A straightforward calculation then shows that

$$\widehat{TS}_A - TS_A^a = \left[\widehat{p}\left(\widehat{q}_A^S - q_A^a\right) - \int_{q_A^a}^{q_A^S} P_A^S(q)\, dq\right] + \left[\widehat{p}\left(q_A^a - \widehat{q}_A^D\right) - \int_{\widehat{q}_A^D}^{q_A^a} P_A^D(q)\, dq\right].$$

Both parts between brackets are positive since $\widehat{p} > P_A^S(q)$ and $\widehat{p} > P_A^D(q)$ for all $q \in \left(\widehat{q}_A^D, \widehat{q}_A^S\right)$. A similar argument applies to market B. There we have, as a difference

$$\widehat{TS}_A - TS_A^a = \left[\int_{q_B^a}^{\widehat{q}_B^D} P_D(q)\, dq - \widehat{p}\left(\widehat{q}_B^D - q_B^a\right)\right] + \left[\int_{\widehat{q}_B^S}^{q_B^a} P_B^S(q)\, dq - \widehat{p}\left(q_B^a - \widehat{q}_B^S\right)\right],$$

where both parts between brackets are positive again, since $P_B^S(q)$ and $P_B^D(q)$ are larger than $\widehat{p}$ for all $q \in \left(\widehat{q}_B^S, \widehat{q}_B^D\right)$.

B Stability analysis

Using the auxiliary variables $x_{A,t} = p_{A,t-1}$ and $x_{B,t} = p_{B,t-1}$ we can express our model as a 5x5 equational system. Linearizing this system along the vector of the steady state equilibrium $\vec{p}_* = (p_A^*, p_B^*, \xi^*)$ leads to the following Jacobian matrix

$$J = \begin{pmatrix}
\frac{\partial p_{A,t}}{\partial p_{A,t-1}}\Big|_{\vec{p}_*} & \frac{\partial p_{A,t}}{\partial p_{A,t-2}}\Big|_{\vec{p}_*} & \frac{\partial p_{A,t}}{\partial p_{B,t-1}}\Big|_{\vec{p}_*} & \frac{\partial p_{A,t}}{\partial p_{B,t-2}}\Big|_{\vec{p}_*} & \frac{\partial p_{A,t}}{\partial \xi_{t-1}}\Big|_{\vec{p}_*} \\
\frac{\partial x_{A,t}}{\partial p_{A,t-1}}\Big|_{\vec{p}_*} & \frac{\partial x_{A,t}}{\partial p_{A,t-2}}\Big|_{\vec{p}_*} & \frac{\partial x_{A,t}}{\partial p_{B,t-1}}\Big|_{\vec{p}_*} & \frac{\partial x_{A,t}}{\partial p_{B,t-2}}\Big|_{\vec{p}_*} & \frac{\partial x_{A,t}}{\partial \xi_{t-1}}\Big|_{\vec{p}_*} \\
\frac{\partial p_{B,t}}{\partial p_{A,t-1}}\Big|_{\vec{p}_*} & \frac{\partial p_{B,t}}{\partial p_{A,t-2}}\Big|_{\vec{p}_*} & \frac{\partial p_{B,t}}{\partial p_{B,t-1}}\Big|_{\vec{p}_*} & \frac{\partial p_{B,t}}{\partial p_{B,t-2}}\Big|_{\vec{p}_*} & \frac{\partial p_{B,t}}{\partial \xi_{t-1}}\Big|_{\vec{p}_*} \\
\frac{\partial x_{B,t}}{\partial p_{A,t-1}}\Big|_{\vec{p}_*} & \frac{\partial x_{B,t}}{\partial p_{A,t-2}}\Big|_{\vec{p}_*} & \frac{\partial x_{B,t}}{\partial p_{B,t-1}}\Big|_{\vec{p}_*} & \frac{\partial x_{B,t}}{\partial p_{B,t-2}}\Big|_{\vec{p}_*} & \frac{\partial x_{B,t}}{\partial \xi_{t-1}}\Big|_{\vec{p}_*} \\
\frac{\partial \xi_t}{\partial p_{A,t-1}}\Big|_{\vec{p}_*} & \frac{\partial \xi_t}{\partial p_{A,t-2}}\Big|_{\vec{p}_*} & \frac{\partial \xi_t}{\partial p_{B,t-1}}\Big|_{\vec{p}_*} & \frac{\partial \xi_t}{\partial p_{B,t-2}}\Big|_{\vec{p}_*} & \frac{\partial \xi_t}{\partial \xi_{t-1}}\Big|_{\vec{p}_*}
\end{pmatrix}$$

The dynamical system is (locally) stable if and only if all eigenvalues of J are less than one in absolute value. Straightforward computations reveal that two eigenvalues are always zero while the remaining three eigenvalues, λ_1, λ_2 and λ_3, are determined by the roots of the polynomial

$$\lambda^3 + a_1\lambda^2 + a_2\lambda + a_3 = 0,$$

where

$$\begin{aligned}
a_1 &= \frac{1}{n_A}\beta {p_B^*}^2 \xi^*(\tau-2)(\tau-1)^2(\xi^*-n_A) + n_A + n_B - \xi^*\tau - 1, \\
a_2 &= \frac{1}{n_A}\beta {p_B^*}^2 \xi^*(\tau-1)^2(\xi^*-n_A)(n_A\tau - n_A - n_B) + \xi^{*2}(\tau-1) \\
&\quad + \xi^*(\tau - n_B) - \xi^* n_A(\tau-1) + n_A n_B - n_A - n_B
\end{aligned}$$

and

$$a_3 = (\xi^* - n_A)(n_B + \xi^* - \xi^*\tau).$$

These eigenvalues, in turn, are less than one in absolute value if and only if

$$\begin{aligned}
1 + a_1 + a_2 + a_3 &> 0, \\
1 - a_1 + a_2 - a_3 &> 0, \\
1 - a_2 + a_1 a_3 - a_3^2 &> 0, \\
3 - a_1 - a_2 + 3a_3 &> 0
\end{aligned}$$

simultaneously hold.[14]
It is worth noting that each of the first three conditions is also a necessary condition for a certain type of bifurcation which may occur in a nonlinear system if solely this condition is violated. That is to say, violation of the first condition is a necessary condition for a saddle-node bifurcation, violation of the second condition a necessary condition for a flip bifurcation and violation of the third condition a necessary condition for a Neimark-Sacker bifurcation.[15]

[14]For different sets of stability conditions for third-order dynamical systems see, e.g. Lines (2007), Chiarella and He (2003) or Gandolfo (1997).
[15]See, e.g. Lines (2007)

In our case, these four stability conditions reduce to

$$
\begin{aligned}
{p_B^*}^2\beta\xi^*(\tau-1)^2(\xi^*-n_A)(\tau n_A-n_A-n_B+\tau-2)&>0,\\
{p_B^*}^2\beta\xi^*(\tau-1)^2(\xi^*-n_A)(2-n_B-n_A+n_A\tau-\tau)+&\\
2n_A(n_A-\xi^*-1)(n_B-1+\xi^*-\xi^*\tau)&>0,\\
{p_B^*}^2\xi^*\beta(n_A-\xi^*)^2(\tau-2)(\tau-1)^2(n_B+\xi^*-\xi^*\tau)-&\\
{p_B^*}^2\xi^*\beta(n_A-\xi^*)(\tau-1)^2(n_A+n_B-n_A\tau)+&\\
n_A(1+n_A-\xi^*)(1+n_B+\xi^*-\xi^*\tau)(1-n_An_B)+&\\
\xi^*n_A(1+n_A-\xi^*)(1+n_B+\xi^*-\xi^*\tau)(n_B+\xi^*-\xi^*\tau-n_A+n_A\xi^*)&>0,\\
{p_B^*}^2\xi^*\beta n_A(\tau-1)^3(n_A-\xi^*)+{p_B^*}^2\xi^*\beta(\tau-2)(\tau-1)^2(n_A-\xi^*)-&\\
{p_B^*}^2\xi^*\beta n_B(\tau-1)^2(n_A-\xi^*)+&\\
4n_A-4n_An_B(n_A-\xi^*)+4n_A\xi^*(\tau-1)(n_A-\xi^*)&>0
\end{aligned}
$$

Taking into account that $p_B^*>0$, $\beta>0$, $0<n_A<1$, $0<n_B<1$ and that $0<\xi(\tau)<n_A$ for all possible τ between 0 and 1 (and hence $\xi^*<n_A$) one can immediately see that the first condition is always fulfilled. In turn, the remaining conditions may be violated for certain parameter combinations. However, one can computationally proof that from these three conditions only the second condition is binding. That is to say, if we calculate the following critical values

$$
\begin{aligned}
\beta_1&=\frac{2n_A(1-n_A+\xi^*)(n_B-\xi^*\tau+\xi^*-1)}{\xi^*{p_B^*}^2(\tau-1)^2(n_A-\xi^*)(n_A-n_A\tau+n_B+\tau-2)}\\
\beta_2&=\frac{n_A(n_A-\xi^*+1)(n_B-\xi^*(\tau+1)+1)(1-(n_A-\xi^*)(n_B-\xi^*\tau+\xi^*))}{\xi^*{p_B^*}^2(\tau-1)^2(n_A-\xi^*)(n_B-(\tau-1)n_A+(\tau-2)(n_B-\xi^*(\tau-1))(\xi^*-n_A))}\\
\beta_3&=\frac{4n_A((n_A-\xi^*)(n_B-\xi^*\tau+\xi^*)-1)}{\xi^*{p_B^*}^2(\tau-1)^2(n_A-\xi^*)(n_A(\tau-1)-n_B+\tau-2)}
\end{aligned}
$$

such that for $\beta>\beta_1$ the second condition, for $\beta>\beta_2$ the third condition and for $\beta>\beta_3$ the fourth condition will be violated, we can show that the following lemma holds.

Lemma 4 *Let $p_B^*>0$, $1>\tau>0$, $1>n_A>0$, $1>n_B>0$ and $n_A>\xi^*>0$. Then β_1, β_2 and β_3 as functions in p_B^*, ξ^*, n_A, n_B and τ satisfy $\beta_1<\beta_2$ and $\beta_1<\beta_3$. Moreover, let $\tau>\tau^*$ then β_1 will also satisfy $\beta_1>0$.*

Proof. The proof is computer assisted and can be accomplished by computationally checking that there exists no set for which the conditions

1. $p_B^*>0$, $1>\tau>0$, $1>n_A>0$, $1>n_B>0$, $n_A>\xi^*>0$ and $\beta_1>\beta_2$
2. $p_B^*>0$, $1>\tau>0$, $1>n_A>0$, $1>n_B>0$ and $n_A>\xi^*>0$ and $\beta_1>\beta_3$

are fulfilled.

Moreover, one can show that for $0<n_A<1$, $0<n_B<1$, $a>0$, $b>0$ and $n_A+n_B>\max\left\{\frac{b-a}{a},\frac{2a}{b}\right\}$ we have

$$\beta_1(\tau^*)=0 \text{ and } \left.\frac{\partial\beta_1}{\partial\tau}\right|_{\tau^*}>0.$$

■

C Quasi-linear utility and consumer surplus

Note that the demand functions can be derived from utility maximization as follows. Assume that the representative consumer in country i has utility function

$$U(y,q) = y + q - \frac{1}{2}q^2,$$

where q is the commodity being studied and y is a composite commodity representing all other commodities and with price 1. The budget equation for the representative consumer is $pq+y=m$, where m is the income of the consumer. Then we can find the preferred consumption bundle of the consumer by substituting the budget equation in the utility function to obtain

$$U(y(q),q) = m - pq + q - \frac{1}{2}q^2.$$

Note that this is a concave function in q, with a unique solution to the first order condition given by

$$-p + 1 - q = 0 \to q^* = 1 - p \text{ and } y^* = m - p(1-p).$$

This is a feasible solution as long as m is sufficiently large: $m > p(1-p)$.

Note that indirect utility is given by

$$V(p,m) = U(y^*,q^*) = m - p(1-p) + 1 - p - \frac{1}{2}(1-p)^2 = m + \frac{1}{2}(1-p)^2.$$

Therefore the chance in utility between two prices is given as

$$V(p',m) - V(p,m) = \frac{1}{2}(1-p')^2 - \frac{1}{2}(1-p)^2 = CS' - CS.$$

Therefore, for this utility function we have exactly that the utility difference is the same as the difference in consumer surplus.

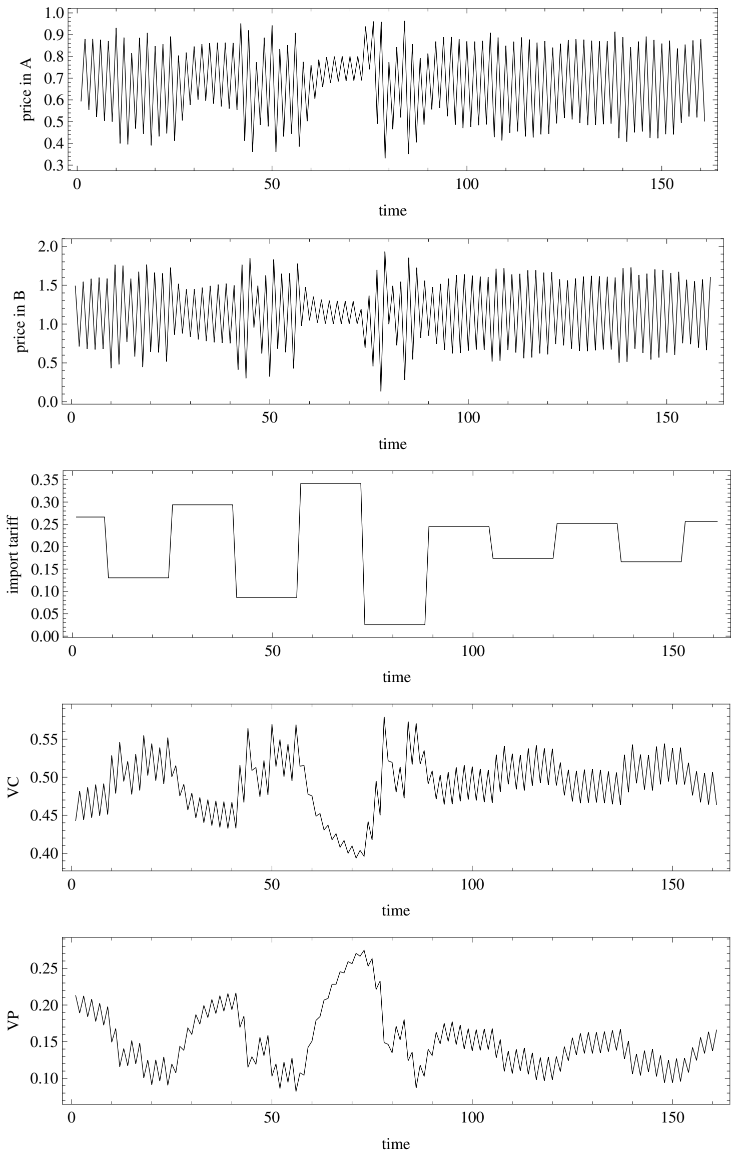

Figure 13: Evolution of prices in region A and B, of import tariff τ and of the realized profits of both consumers and producers in region B. Import tariffs are endogenously determined in the political arena and adjusted every 16^{th} period, i.e. once in the typical life cycle of a government.

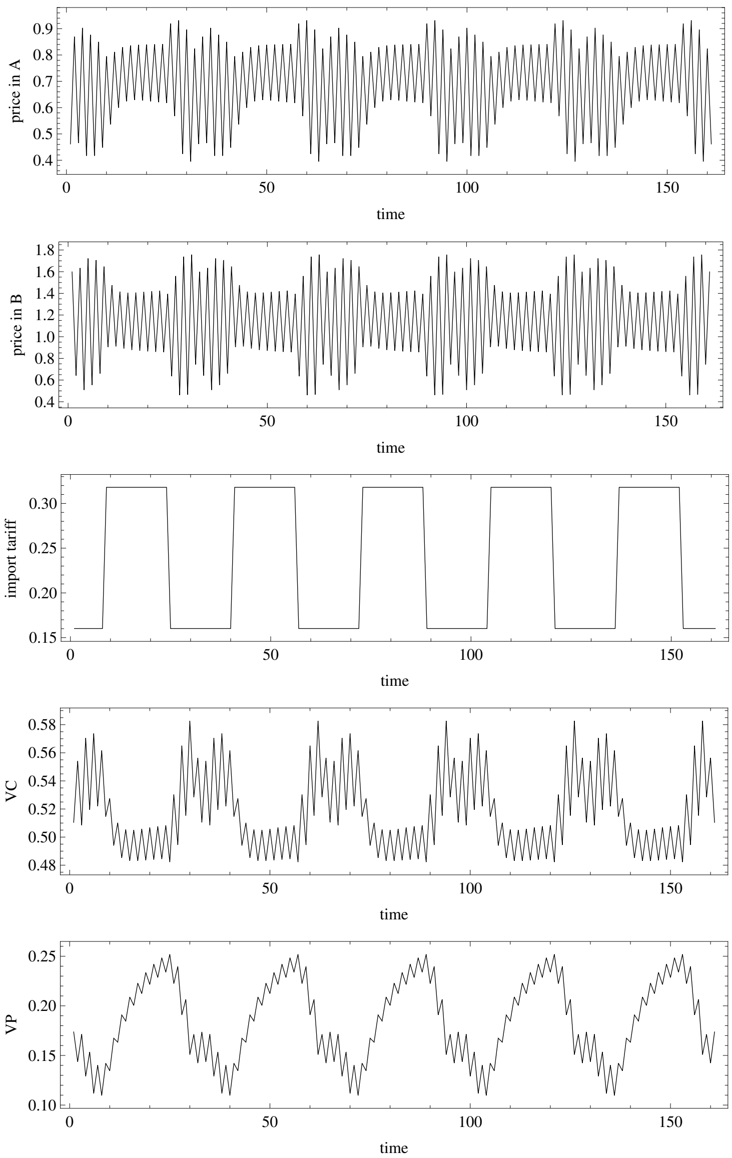

Figure 14: Evolution of prices in region A and B, of import tariff τ and of the realized profits of both consumers and producers in region B. Import tariffs are endogenously determined in the political arena and adjusted every 16^{th} period, i.e. once in the typical life cycle of a government. Moreover, revenues out of import tariffs are now redistributed among consumers in region B. Optimal (stabilizing) import tariff: $\tau \approx 0.344$.

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