Óscar Afonso
Faculty of Economics and CEFUP, University of Porto
oafonso@fep.up.pt
orcid.org/0000-0002-9597-9850
Carlos Pinto
Faculty of Economics of the University of Porto
up200103202@fep.up.pt
Paulo Beleza Vasconcelos
Faculty of Economics and CMUP, University of Porto
pjv@fep.up.pt
orcid.org/0000-0002-7132-880X
DOI: https://doi.org/10.14195/2183-203X_52_2

Intra-Industry Trade: Economies of Scale Revisited

Comércio Intra-Indústria: Economias de Escala Revisitadas

Óscar Afonso
Carlos Pinto
Pedro Beleza Vasconcelos

Received for publication: September 15, 2020
Revision accepted for publication: November 22, 2020

ABSTRACT
The Krugman model shows that international trade can trigger mutual gains for the participating countries even when they are similar in technology and endowments. The emerging intra-industry trade between countries is based on economies of scale, the exchange of different types of products produced under monopolistic competition, and heterogenous preferences. We extend the baseline model by considering two dynamic settings, with special focus on the producer. The former reveals that gains in the long run are concomitant with short term losses for workers in the smaller country due to the competitiveness gap. Until the competitiveness gap is narrowed, lower nominal wages or the decline in the exchange rate are required for the country to keep its production capacity and a balanced international trade position. Furthermore, we consider that the cost structure of an industry also depends on factors that cannot depreciate via exchange rate. Here, the employees of companies that are at a competitive disadvantage, due to a low efficiency starting point, may feel a negative impact during the transition as they lose purchasing power. While the country as a whole gains, some country agents might lose, at least in the short term. Results are illustrated numerically, using MATLAB, calibrated against the example in Krugman and Obtsfeld (2006).
Keywords: Krugman; intra-industry trade; economies of scale; monopolistic competition.

JEL Classification: D31; H23; I38.

RESUMO
O modelo do Krugman mostra que o comércio internacional pode surgir e conduzir a ganhos mútuos para os países participantes, mesmo quando são semelhantes em tecnologia e dotações. O comércio intra-indústria emergente entre países baseia-se em economias de escala, no intercâmbio de variedades diferenciadas dos produtos produzidos sob a concorrência monopolista e nas preferências heterogéneas. Alargamos o modelo de base, considerando duas configurações dinâmicas, com especial enfoque no lado do produtor. A primeira extensão

revela que os ganhos a longo prazo são concomitantes com perdas a curto prazo para os trabalhadores do país mais pequeno devido à diferença de competitividade. Até que o fosso de competitividade seja preenchido, é necessária uma diminuição dos salários nominais ou uma diminuição da taxa de câmbio para que o país mantenha a sua capacidade de produção e uma posição comercial internacional equilibrada. Depois, consideramos que a estrutura de custos de uma indústria também depende de fatores que não podem desvalorizar através da taxa de câmbio. Neste contexto, os trabalhadores de empresas que têm uma desvantagem competitiva, devido a um ponto de partida de baixa eficiência, podem sentir um impacto negativo durante um período de transição, perdendo o poder de compra. Enquanto o país como um todo ganha, alguns agentes dentro do país podem perder, pelo menos a curto prazo. Os resultados são ilustrados numericamente, utilizando o MATLAB, calibrado tendo por base o exemplo em Krugman e Obtsfeld (2006).

Acknowledgements:: This research was partially supported by CEFUP (UIDB/04105/2020 *and* UIDP/04105/2020) and by CMUP (UID/MAT/00144/2019), which is funded by FCT with national (MCTES) and European structural funds through the programs FEDER, under the partnership agreement PT2020.

Óscar Afonso
Carlos Pinto
Paulo Beleza Vasconcelos

Intra-Industry Trade: Economies of Scale Revisited

1. Introduction

According to traditional international trade theory, Classic and Neoclassic, trade could only arise, and lead to mutual gains for countries, measured by the increase in the utility or level of welfare, if they differed in technologies (Classic, David Ricardo) or in their endowments (Neoclassic, Hecksher-Ohlin); moreover, international trade would consist only of exchanges of products in different product categories (inter-industry trade) – e.g., Appleyard et al. (2008) and Caves et al. (2007).

However, international trade is manly intra-industry and also generates gains for the involved countries as shown for instance by Balassa (1967) and Kravis (1971). It was necessary to wait until the year 1979 for the seminal Krugman's paper "Increasing Return, Monopolistic competition and International Trade", to get into the new wave of the international-trade theory. In line with Krugman (1979) model, this paper also showed an alternative explanation to the international trade, based on the fundamental concepts of economies of scale and the so-called "love for variety" preferences.

Hence, following the point of view proposed by Krugman (1979), we extend the Krugman and Obstfeld (2006) to introduce trade based on internal economies of scale in production.[1] Such trade in similar productions is denominated intra-industry trade. In this case, international trade can occur even when there are no technological nor endowment differences between countries. Internal economies of scale give rise to imperfectly competitive markets and Krugman and Obstfeld (2006) consider monopolistic competition. In this case, there are a number of firms in an industry, each of which produces a differentiated product. Demand for its good depends on the number of other similar products available and their prices. This type of model is useful for illustrating that trade improves the trade-off between scale and variety available to a country. In an industry described by monopolistic competition, a larger market, such as that which arises through international trade, lowers average price by increasing production and lowering average costs and makes available for consumption a greater range of goods. While an integrated market also supports the existence of a larger number of firms in an industry, the model presented in this paper does not make predictions about where these industries will be located.

In order to illustrate the results, the extended models are implemented using MATLAB, calibrated against the example in Krugman and Obtsfeld (2006), and solved numerically.

After this short introduction, Section 2 summarizes the setup of the model, and presents two new dynamic extensions, with and without labor costs. Section 3 illustrates the numerical resolution of the baseline model and the two dynamic extensions. Section 4 concludes.

2. The model

The model uses economies of scale, differentiated products and heterogeneous preferences to explain intra-industry trade. The essence of the model is as follows: (i) preferences

[1] Economies of scale can by external economies whereby the cost per unit relies on the size of the industry, but not necessarily on the size of the firm, or can be internal economies whereby the production cost per unit of output depends on the size of the individual firm, but not necessarily on the size of the industry.

are heterogeneous between and within countries; (ii) production experiences economies of scale; (iii) goods are differentiated Industries within a country will produce goods, which are targeted for the majority of their home consumers, thereby, exploiting economies of scale. However, not all consumers have the same preferences. Some will have preferences for the goods produced elsewhere. These consumers then wind up buying imported goods. The converse is also true: some portion of foreign consumers will have a greater preference for home country goods and home country winds up exporting to this market. With economies of scale there are only a feasible small number of firms to satisfy world demand.

2.1. Baseline model

Firstly, it is characterized the autarkic equilibrium in a monopolistic competitive industry. Then, it is analyzed the effect of international trade on that equilibrium. In the standard model of monopolistic competition, all firms are assumed to be symmetric; that is, "the demand function and cost function are identical for all firms" (even though they are producing and selling somewhat differentiated products) (Krugman and Obtsfeld, 2006). Economies of scale can be modeled by the following total cost linear equation:

$$C = F + c.Q, \tag{1}$$

where F is a fixed cost, Q is the production level, and c the constant firm's marginal cost. Indeed, this linear cost function implies economies of scale since the larger the firm's production the less is the fixed cost per unit. Specifically, the firm's average cost, AC, is:

$$AC = \frac{C}{Q} = \frac{F}{Q} + C = \frac{n.F}{S} + C, \tag{2}$$

where S is the size of the industry's market, which is fixed and does not depend on price, and n is the number of firms. Equation (2) implies that the average cost declines as Q increases since the fixed cost is spread over a larger output. One implication of this cost function is that, given the size of the industry's market, S, the more firms there are in the industry the higher the AC of each firm. Indeed, if the number of firms, n, increases, each firm will sell and produce less since $Q = \frac{S}{n}$ and, therefore, will have an higher average cost. This upward sloping relationship between n and AC is represented in Figure 1 by the blue, red, and green lines.

In turn, in a monopolistic competitive industry, the demand biased towards the product of the typical firm, Q, decreases with its own price, P, and the number of firms in the industry, n, and increases with the size of the total demand for the industry's product, S, and the average price charged by the firm's rivals, P^*. With these assumptions, all it is needed to understand the equilibrium of the industry is the number of firms, the quantity produced by each firm, and the market price, which is also the price charged by each individual firm and their average cost. In a model "in which consumers have different preferences and firms produce varieties tailored to particular segments of the market" (Krugman and Obstfeld 2006, p. 117), the following specification for the demand is proposed:

$$Q = S.\left[\frac{1}{n}\ b.(P - P^*)\right], \tag{3}$$

where b is a constant term representing the responsiveness of a firm's sales to its own price, P, and the average price charged by its competitors, P^*. This equation can be given the following intuitive explanation: "if all firms charge the same price, each will have a market share $\frac{1}{n}$. A firm charging more than the average of the other firms, $P > P^*$, will have a smaller market share, while a firm charging less, $P < P^*$, will have a larger share" (Krugman and Obstfeld, 2006, p. 117). A simplifying assumption is that total industry sales S are unaffected by the average price charged by the firms in the industry. That is firms can gain customers only at each other's expense. This is an unrealistic assumption but simplifies the analysis and helps focus on the competition among firms (Krugman and Obstfeld 2006, p. 118). A crucial implication of equation (3) is that, given the size of the industry's market, S, the more firms there are, the lower the (profit-maximizing) price each firm will charge since "the more firms there are, the more intense will be the competition among them and hence the lower the price. This turns out to be true in this model, but proving it takes a moment" (Krugman and Obstfeld 2006).

To solve the model, the marginal revenue, MR, function from the demand curve facing the typical firm (3), which is given by $MR = P - \frac{Q}{S.b}$. Afterwards, equalizes the to the marginal cost and finally solves the resulting equation to obtain a relationship between (the profit-maximizing price) and (the number of firms), resulting:

$$P = c + 1\ \frac{1}{b.n}. \tag{4}$$

Equation (4) informs us that the more firms there are in the industry, n, the greater the competition and, thus, the lower the price, P, charged by each firm and this downward sloping relationship between P and n is represented by the black downward sloping curve in Figure 1.

Concerning the industry equilibrium, given free entry and exit, it is given by the zero--profit condition; i.e., by equations (2) and (4) the price must equal the coverage cost:

$$P = AC. \tag{5}$$

This equilibrium is defined by the number of firms and the average price they charge. It corresponds to the point of intersection between the black curve and each of the other curves in Figure 1, where there are n firms in the industry and where the profit maximizing price, P is defined; the equilibrium point (n, P) is a stable equilibrium: If the number of firms is

$n_1 < n$, the profit maximizing price P_1 is higher than the average cost AC_1. Thus, established firms are making above-normal profits and, as a result, new firms enter the market. This drives the price down and the average cost up until they are equal at the equilibrium point. In turn, if the number of firms is $n_2 > n$, the opposite happens.

The key contribution of this model is to show that international trade, by creating a combined market larger than any of the national markets that comprise it, allows more varieties of each product to be produced, at lower average costs, than in any national market alone. Krugman's (1979) demonstration is based on the following, bearing in mind Figure 1 from the Krugman and Obstfeld (2006) example: in autarky, the industry equilibrium in each country is at point (6, 10.000) for country A and (8, 8.750) for country B; when international trade starts, the market size of the industry increases, S, and, given the number of firms, n, the sales of each firm rise, $Q = \frac{S}{n}$. As a result, the AC of each firm falls for any given n. In turn, international trade and the ensuing increase in the size of the market do not have any effect on the curve $P = 1 + \frac{1}{b.n}$, which relates the profit-maximizing price with the number of firms since the size of the market does not enter into the equation that defines P.

Conclusion: in Figure 1 the industry equilibrium shifts toward the equilibrium point (10, 8.000), which means that the number of firms increases, while the price falls. As stated in Krugman and Obstfeld (2006), consumers prefer to be part of a large market than a small one since a greater variety of products is available at a lower price. An increase in S due to international trade shifts the average cost curve downwards thus lowering the price of the product, while increasing the number of viable firms. The greater the number of firms the more the number of differentiated products, thus international trade provides consumers with greater variety and lower prices. The $P = 1 + \frac{1}{b.n}$ curve is independent of S and, therefore, does not shift.

Note though that with a non-horizontal $P = 1 + \frac{1}{b.n}$ curve, the number of firms that exist in the long run with international trade is less than the sum of the numbers across countries in autarky. It is also useful to note the impact of the different parameter and variables in the two equations: (i) c, the marginal cost, has a positive impact on both average cost and price. The impact is 1-to-1, which can be seen in the derivatives of equations (2) and (4) with respect to c; (ii) F, the fixed cost, impacts directly the average cost (2) such that the higher the fixed costs, the higher the average cost; (iii) b, the consumer price sensitivity, affects directly the market price (4) and the higher b the lower the price will be; (iv) S, the size of the market, the larger the more firms can produce and, thus, the lower average cost (2) will be; (v) n, the number of firms, implies that, all other things being equal, the larger the number of firms, the higher the average cost (2) in the market. This is because, a higher number of firms for the same quantity demanded will let each firm produce less. Since the model has economies of scale, lower scale at the firm level results in higher average costs. On the other hand, the number of firms has the opposite effect on price (4). Everything else constant, the more firms there are, the lower the market price will be.

It is clear from Figure 1 that the larger the market of the firms, the more savings they can obtain from economies of scale and the more varieties of the product a customer have access to. We also know the implications for the openness to consumers.

2.2. Dynamic model with labor costs

We intend to explain how firms of an non-homogeneous good and countries adjust after international trade openness. The cost structure has a fixed and a variable component and is initially equal in both countries in local currency. The demand remains inelastic, the size of the market is again fixed and does not respond to variations in price, the level consumption and production is the same in every period, there is no price differentiation, external trade balance is always equal to zero and countries can not have trade deficits.

To understand the dynamic implications of the model, we now consider that firms are unable to adjust immediately to the new optimal scale due to, for example, lack of information on the true size of the market, capital adjustment costs, labor market rigidity, regulatory constraints. To consider these rigidities, we assume that, each period, firms only cover part of the gap between their current production capacity and the optimal production capacity:

$$Q_t = (1 - \alpha)Q_{t-1} + \alpha Q^*, \quad (6)$$

where Q^* represents the optimal firm's production after international trade and Q_{t-1} is the production in the previous time period since t represent the present time period. We consider that labor is the productive factor. The fixed cost is now the number of working hours that are needed regardless of the quantity produced in addition to the additional number of working hours required for each unit produced. Moreover, after international trade is allowed, the price of the product is the same worldwide and equal to the price in the most competitive country. This is a result of the zero profit condition – average cost is equal to price – and less competitive firms can adjust their wage costs to ensure zero profit condition. This adjustment can be performed through nominal adjustments in wages or through the exchange rates. For the purpose of the model, it is irrelevant what is the method used to adjust wage costs. For simplicity, we assume that is done via exchange rates. Hence, this assumption means that there is no other tradable good, and we can assume that this product is the only tradable good in the economy. This will also allow us to understand the exchange rate implications of efficiency convergence and international trade.

We start by considering that countries are in autarky, $t = 1$. Then, in the following period, the countries start trading with each other and the price of the product equalizes for both countries. However, the firms in each country have different sizes, with the larger country having larger firms, closer to the optimal scale. Firms in both countries adjust at a rate α towards the optimal scale. Hence, replacing n by $\frac{S}{Q}$ in equations (2) and (4) results:

$$AC = \frac{F}{Q*} + c, \quad (7)$$

$$P = c + \frac{Q*}{b.S}. \quad (8)$$

We keep the zero profit assumption, so average cost will be equal to price. Equalizing (7) and (8) and solving with respect to Q^*, we get the optimal value for the quantity produced by the firms, $Q^* = (S.b.w_t.l)^{0.5}$. However, now firms do not immediately start producing that quantity since, from (6), firms in each country $i = A,B$ follow an autoregressive process with α representing the flexibility of the economy. Hence, Q^i, $i = A,B$, evolves according to the rule:

$$Q_t^i = (1 - \alpha^i)Q_{t-1}^i + \alpha^i Q^*. \tag{9}$$

Hence, Q^i can be different from Q^* for some periods of time, depending on the adjustment term α^i. However, since zero profit assumption remains for all firms, the most competitive firms (with the larger scale) will still have price equal to the average cost. Additionally, since countries are now a single market for the product, there are a worldwide single price. Thus, to compete in the market, the other firms need to adjust factor costs.

Fixed costs represent now the number of working hours required for a firm to function regardless of quantity produced, multiplied by the wage per hour: $F_t = w_t l$, where F is the fixed cost per firm, w is the wage per hour, and l is the fixed number of working hours required for the firm to function in each period, regardless of produced units. In turn, the variable cost depends on the number of hours required to build one unit of the product multiplied by the wage rate: $c_t = w_t h$, where c is the variable cost and h represents the working hours required to produced one additional unit of product. Replacing these expressions in equation (2), the new average cost is

$$AC = \frac{W_t l}{Q_t} + W_t h. \tag{10}$$

Given that $P^A = P^B$, and $P = AC$ then $\frac{W_t^A l}{Q_t^A} + W_t^A h = \frac{W_t^B l}{Q_t^B} + W_t^B h$. For these equality to hold, $Q_t^B < Q_t^B, W_t^B < W_t^B$. In summary, the economy is ruled by the following dynamic system in each period of time:

$$Q^* = (S.b.w_t.l)^{0.5} \tag{11}$$

$$Q_t^A = (1 - \alpha^A)Q_{t-1}^A + \alpha^A Q^* \tag{12}$$

$$Q_t^B = (1 - \alpha^B)Q_{t-1}^B + \alpha^B Q^* \tag{13}$$

$$P_t = \min\left(w_t^A h + \frac{Q^A}{b.S},\ w_t^B h + \frac{Q^B}{b.S}\right) \tag{14}$$

$$P_t = P_t^A = P_t^B = AC_t^A = AC_t^B \tag{15}$$

$$AC_t^A = \frac{w_t^A l}{Q_t^A} + w_t^A h = AC_t^B = \frac{w_t^B l}{Q_t^B} + w_t^B h. \tag{16}$$

2.3. Dynamic model without labor costs

In the previous Subsection, we have considered that the only costs faced by the firms were labor costs. Both fixed and variable costs were assumed to be labor related. Now, we change this assumption to account for the fact that firms might have some costs that are not possible to devalue via exchange rate. We can think of several examples such as internationally traded raw materials, oil, or other intermediate products where the price does not depend on the internal dynamics of the economy. For that purpose, we will now make the variable cost a constant, c, just as in the baseline case in Section 2. This parameter c represents the cost of the additional raw materials required to produce one more unit of the product. Since for the purposes of this Subsection, it is irrelevant whether labor costs are only partially or fully excluded from the variable component, we exclude labor costs since it is more intuitive and algebraically easier to illustrate. Hence, in relation to the previous case, we have this main change: the variable costs are $c_t = c$ to produce an additional unit of the product (not possible to deflate via exchange rate). The new average cost is thus:

$$AC = \frac{W_t l}{Q_t} + c. \tag{17}$$

Given that $P^A = P^B$ and $P = AC$ then $\frac{W_t^A l}{Q_t^A} + c = \frac{W_t^B l}{Q_t^B} + c$. The economy is now ruled, at each period of time, by the following dynamic system:

$$Q^* = (S.b.c)^{0.5} \tag{18}$$

$$Q_t^A = (1 - \alpha^A) Q_{t-1}^A + \alpha^A Q^* \tag{19}$$

$$Q_t^B = (1 - \alpha^B) Q_{t-1}^B + \alpha^B Q^* \tag{20}$$

$$P_t = \min\left(c + \frac{Q^A}{b.S},\ c + \frac{Q^B}{b.S}\right) = c + \min\left(\frac{Q^A}{b.S}, \frac{Q^B}{b.S}\right) \tag{21}$$

$$P_t = P_t^A = P_t^B = AC_t^A = AC_t^B \tag{22}$$

$$AC_t^A = \frac{w_t^A l}{Q_t^A} + c = AC_t^B = \frac{w_t^B l}{Q_t^B} + c. \tag{23}$$

3. Numerical resolution

3.1. Baseline model

In the baseline case we consider the following values for parameters and exogenous variables in line with Krugman and Obstfeld (2006): the market price sensitivity, b, is $\frac{1}{30.000}$, the home market size, S^A, is 900.000, the foreign market size, S^B, is 1.600.000, the fixed cost, F, is 750.000.000, and the marginal cost, c, is 5.000. Results are shown is Figure 1.

Figure 1: Baszeline case. The upward sloping curves represent the relationships between n and AC. The downward sloping curve represent the relationship between n and P

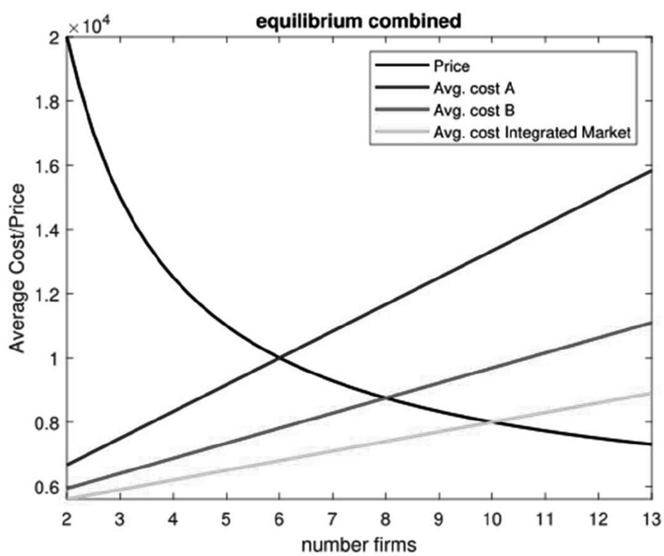


Table 1: Baseline case. Main results in autarky and under international trade: results for countries A and B, integrated markets, and the comparison between both countries and the integrated markets

	country A	country B	integrated markets (IM)	comparison IM & A	comparison IM & B
total sales (× 1000)	900	1600	2500	1600	900
price	10000	8750	8000	-2000	-750
average cost	10000	8750	8000	-2000	-750
sales/firm (× 1000)	150	200	250	100	50
number of firms	6	8	10	4	2

3.2. Dynamic model with labor costs

Now, we adapt the baseline case to our dynamic extensions. The fixed number of hours required per firm, l, is 15.000.000, the number of working hours required per additional unit of product, h, is 100, the wage per hour, w, is 50, the flexibility parameter, α, is 0.1. Thus, the variable cost is hw. The wage is in international units of currency (IUC), which coincides with the value in local currency in period $t = 1$ for both countries. We assume that nominal wages have downwards rigidity in local currency, so downwards adjustments in wages are done via exchange rate.

In period $t = 1$, we assume the autarky equilibrium calculated in the previous Subsection – see Table 1: $Q^A = 150.000$; $Q^B = 200.000$; $n^A = 6$; $n^B = 8$; $P^A = 10.000$; $P^B = 8.750$; Q^* is the quantity that resulted from the integrated markets equilibrium – see Table 1: $Q^* = 250.000$; $n^* = 10$; $P^* = 8.000$.

In this case we also need to observe what happens in terms of number of working hours in the economy to produce, e, the price level of the product in each country divided by the price of the product in the cheapest country in autarky, P, the real wage that is the wage rate divided by the price level, w^r, and the exchange rate corresponding to the price of the product in local currency in country B divided by the price of the product in local currency in country A (it is easy to prove that, in this case, it is equal to the ratio of nominal wages in IUCs). The exchange rate is assumed to be 1 in the $t = 1$, although the value has no special meaning in autarky.

Figure 2: Dynamic model with labor costs – main results

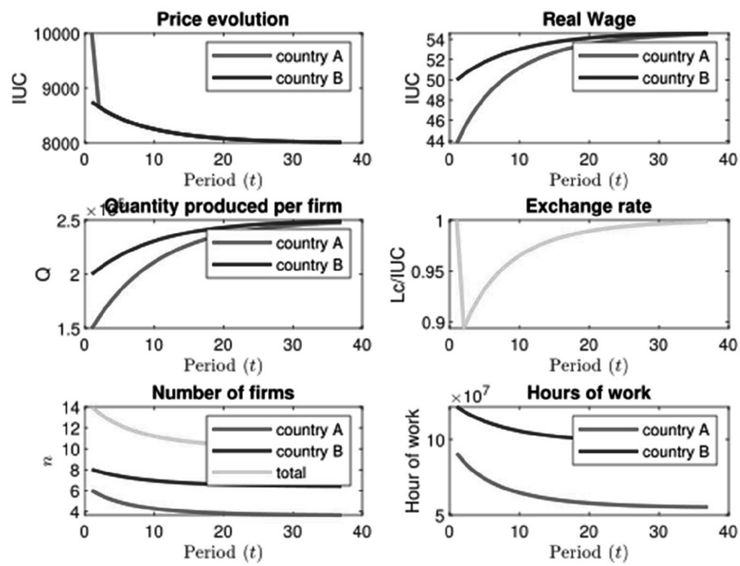


Figure 2 summarizes the main results. In the first period, both economies are in autarky. Under international trade the product price is the same in both countries, representing a larger gain for the consumers initially in the smaller country who had to pay a larger price for the product. It is also worth noting that the price does not move immediately towards the equilibrium price defined in the previous assignment. This is because firms do not reach the optimal scale immediately after international trade becomes possible. The optimal quantity produced per firm (the scale of production) is 250.000. With a flexibility parameter of $\alpha = 0.1$, the economies take about 37 periods to reach the optimal scale; however, most of the gains are obtained in the first 15 periods. In the first periods there is a significant difference in scale between firms in the originally smaller *A* and the originally larger market *B*. That difference starts to vanish over time. Towards the end, firms in both countries achieve similar scale, operating at the same level of efficiency. Given that, by assumption, market size is fixed, this additional scale by individual firms will result in less firms as the ones incapable of scaling-up are eliminated or merged.

Although consumers will not get immediately the full benefit of the price reduction (specially consumers in *B*), they still benefit from additional choices as soon as the countries open to international trade. Assuming that the varieties originally available in the smaller country are not a sub-group of the ones available in the large country, even the consumers in the large country benefit from additional varieties of the product. In the extreme case where the product varieties originally available in the two countries are mutually exclusive, the consumers benefit more from in terms of product varieties in the transition period than in the final equilibrium.

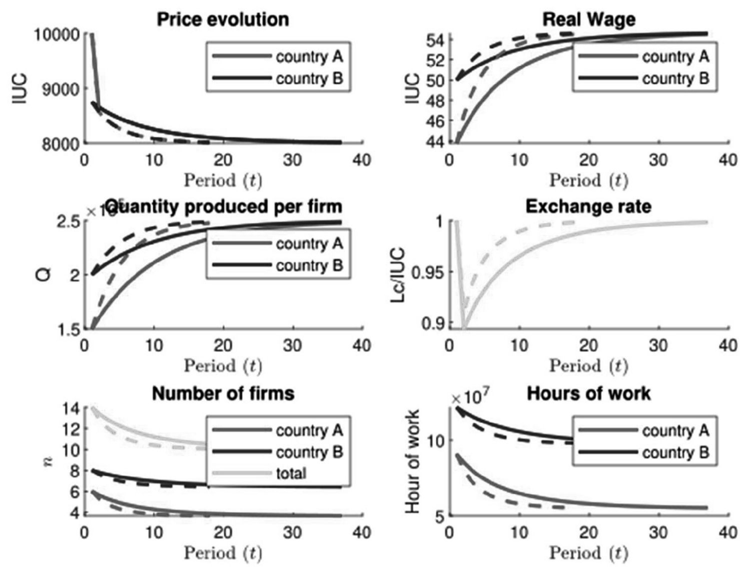
In summary, from the consumer perspective, there are some big immediate gains for consumers in the smaller country *A* who can see a large price drop after international trade, benefiting from the production efficiency of the trade partner. Consumers in the larger country *B* also benefit from a lower price, but are restricted by the capacity of its firms to optimize. Both can benefit significantly by additional varieties, but that benefit decreases during the transition period as the industry consolidates.

The number of hours of work required to produce the fixed quantity (remember we have inelastic demand and no trade deficits/surpluses) goes down over time as firms optimize, meaning that firms need less and less workers or the workers can work less and less hours to produce the same. As a consequence, the real wage per hour goes up over time. In the larger country *B*, the real wage per hour in the first period corresponds to the nominal wage as per the normalization defined in the previous chapter. In the smaller country *A* the nominal wage is adjusted by the price of the product, starting at a lower point. With international trade the real wages converge over time.

The exchange rate is calculated assuming that nominal wages in local currency have full downwards rigidity. They will not be lower than 50 units in local currency as per the initial equilibrium. If we assume a parity starting point, the smaller country will have to do a sharp devaluation once the economy opens up to international trade. However the exchange rate value in autarky has little meaning since, without trade and international flows, there is no real exchange rate setting mechanism. The main take away here is that, as productivity in the smaller country converges with that of the larger country, the currency of the small country will gain in value over time.

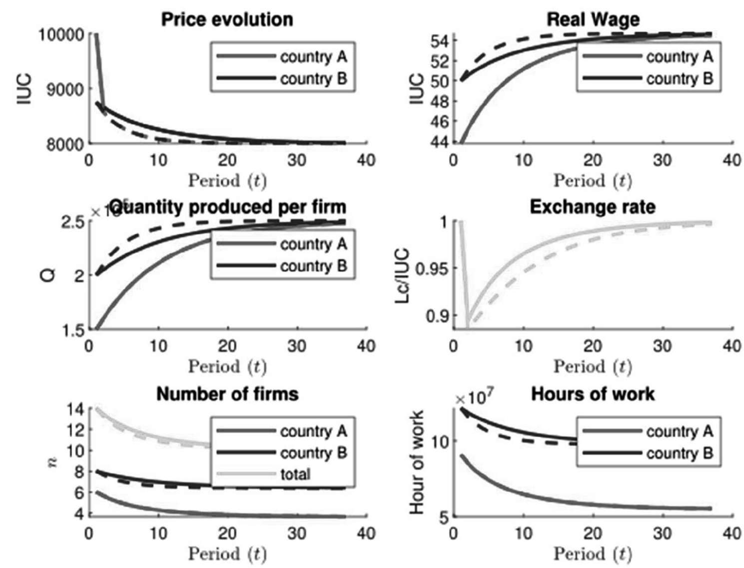
In terms of sensitivity analysis, we start by looking at the speed of adjustment, α. We first observe what would be the impact of doubling the adjustment rate in both countries (a proxy for increasing the flexibility of the economy). The outcomes can be seen in Figure 3. The old scenarios remain there for comparison and the new scenarios are represented with dotted lines. As expected, a higher adjustment rate leads to a faster movement towards the final equilibrium. It is interesting to notice that double the rate of adjustment will make the adjustment period last for roughly one third of the original time. Both countries benefit, but it is obvious by observing the chart that the smaller country *A* gets in absolute and relative terms bigger gains in terms of scale and real wage. The devaluation requirement in the period after opening up to international trade is also lower and parity is achieved faster.

Figure 3: Dynamic model with labor costs,



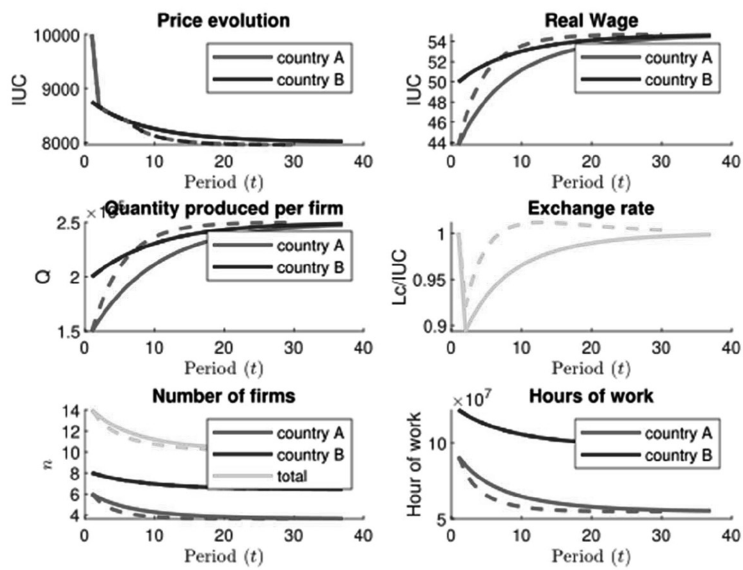
We are assuming so far that the economies' flexibility factor moves in parallel in both countries. We now check the cases in which the flexibility factor is larger only in one of the countries. First, we will assume that $\alpha^B = 0.2$, while α^A remains at 0.1 – see Figure 4. The additional flexibility allows the large economy to increase real wages, firms scale faster, as expected. Overall market price also lowers, which benefits consumers in both countries. So, increasing economic flexibility in one country actually benefits its trade partners indirectly. In order to compensate for the additional gap in competitiveness, the currency in the small country is forced to decline further when opening up to trade and remain below for all periods until equilibrium is reached.

Figure 4: Dynamic model with labor costs, $\alpha^A = 0.1$ and $\alpha^B = 0.2$



Now we check the case in which the flexibility factor is larger in the smaller economy, which, by considering $\alpha^A = 0.2$, becomes more flexible. The outputs are summarized in Figure 5. With additional flexibility, firms can adjust quicker to the new equilibrium. They can adjust so quick that the initial competitiveness advantage coming of the large economy resulting from more scale disappears after five periods. After five periods firms in country A become more efficient and closer to the optimal scale. As such, the real wage in the small economy also becomes higher. The exchange rate even remains slightly above parity until the large country achieves equilibrium. The roles in price determination also change: it is now the turn for consumers in the large country to benefit from lower prices due to the additional competitiveness of the smaller economy.

Figure 5: Dynamic model with labor costs, $\alpha^A = 0.2$ and $\alpha^B = 0.1$

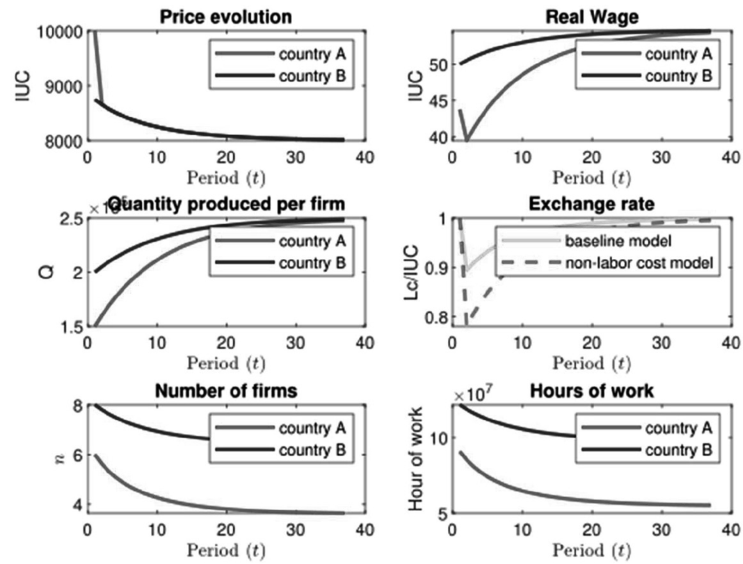


In summary, the economy flexibility factor is crucial to understand the length of the adjustment period, and the currency devaluation requirements. Inflexibility in the economy drives large devaluations and real wage losses for long periods of time.

3.3 Dynamic model with non-labor costs

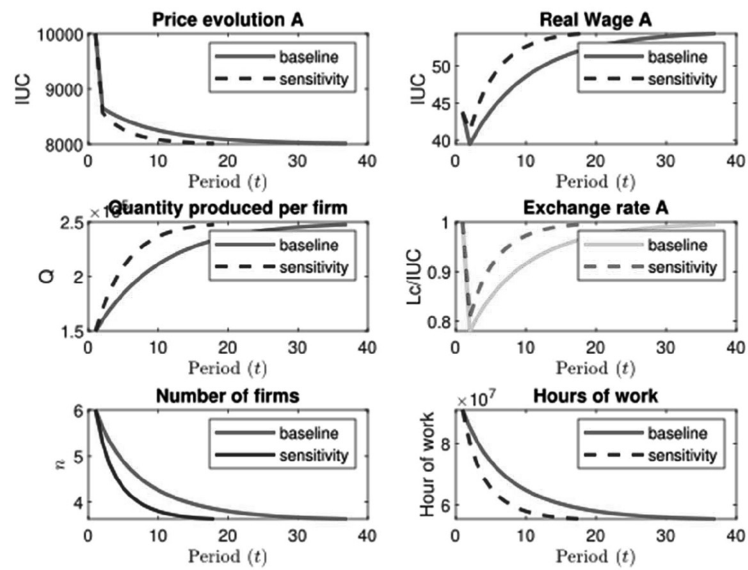
This model drops the parameter h and regains the parameter c, considering that $c = 5000$ matches the initial value for the variable cost both in the baseline model and in the dynamic model with labor costs. Figure 6 summarizes the main results. If we compare it with Figure 2, it is easy to conclude that nothing has changed. Both the final equilibrium and the path towards that equilibrium remain unchanged. This happens because the price level of the firms' optimization path are determined by the economy's flexibility and the path of the most efficient economy, which are unaltered by a shift in how the variable costs are calculated. For the same values of α, same final equilibrium and same initial equilibrium, these curves remain unchanged. The price declines as much as in the previous model. However, the less competitive economy is unable to devalue all the production costs to match the price decline. There is a portion of the costs that are not possible to devalue via exchange rate. The implication of this is that the costs that can be devalued, need to be devalued more than before. Hence, the exchange rate will have to decrease further in order to ensure that firms' average costs in IUC decline as much as before to regain competitiveness.

Figure 6: Dynamic model with non-labor costs – main results



Now, the exchange rate declines further in the initial moment when international trade starts, followed by a quicker recovery than before, reaching equilibrium at the same time. However, the exchange rate in this model remains always below the exchange rate in the previous model, only meeting in the end where both exchange rates meet parity. The exchange rate differences are significant in the initial periods of the adjustment when the scale differences are higher and fixed wage costs represent a higher proportion of the cost structure. As the firms scale up, gain economies of scale and fixed wage costs represent a lower proportion of total costs, the exchange rate in this model becomes more similar to the previous model. It is now important to observe the impact of this exchange rate evolution in the real wage. In the previous model, the exchange rate decline in the small economy was of the exactly same magnitude as the price decline. One (the exchange rate) was a direct response to the other. The impact of this was that the real wage never declined after international trade. The real wage started at the same point as in autarky, increasing from there as a result of firms scaling up and gaining efficiency.

Figure 7: Dynamic model with non-labor costs, $\alpha^A = \alpha^B = 0.2$

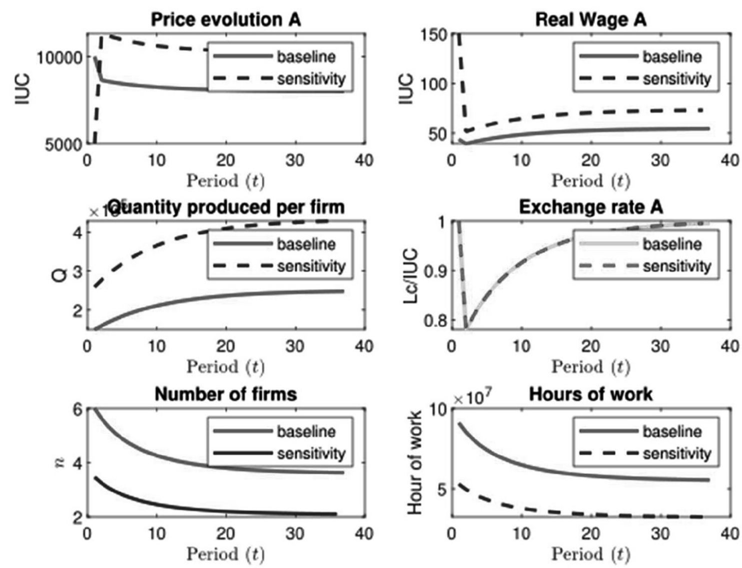


Nothing changed in the real wage of the large country B. The significant change occurs in the real wage of country A. The real wage benefits from a decrease in the product's price just as in the previous model, but it is affected negatively by the decline in exchange rate. This time, the decline in exchange rate is larger than the decline in price, so, unless the economy's flexibility is very large, the real wage will decline in the period after international trade starts. Hence, workers of the most inefficient country producing the tradable product can actually have a short-term decline in their purchasing power after international trade. Thus, while consumers (that in this example can be seen as the people working in the non-tradable sector) benefit from the international trade, workers can see their purchasing power decline.

In terms of the sensitivity analysis, we start by looking at variations in the economy's flexibility factor α. If the factor is double the original value, as expected, exchange rate decreases less and returns to parity faster than in the main model – Figure 7. The real wage also returns faster to the value before international trade, rising faster above it afterwards. Unsurprisingly, we have the opposite situation when we take a flexibility factor half of the original value.

In conclusion, the more flexible the economy is, the shorter is the period workers spend with a net loss in real salary after international trade. As firms are allowed to grow, consolidate and scale-up, they increase efficiency, produce more at a lower cost leading to an increase in exchange rate, which raises workers' real wage.

Figure 8: Dynamic model with non-labor costs, c = 15.000



The second sensitivity worth analyzing is the weight of the non-labor costs in firms' cost structure. To do that, we have tripled the non-labor variable cost, increasing it from 5.000 to 15.000 – Figure 8. The starting point of the real wage is higher because (as mentioned in the beginning) it is indexed against the larger economy. But the interesting insights are twofold: the exchange rate stays exactly the same as the original model. This occurs because the relative differences in productivity (although lower in absolute value) remain unchanged. Second, and most importantly, the drop in real wage is more steep and it also takes longer to regain the same level of real wage as before international trade. Higher variable costs impossible to devaluate do not erase relative productivity differences, but decrease the potential gains of efficiency that make real wages increase over time. The higher the non-labor component of the cost structure, the more the workers will see their real wages falling and the longer it will take until they start gaining from international trade deals.

4. Concluding remarks

A larger market from international trade allows firms to produce more and benefit from additional economies of scale. This, in turn, is reflected in lower consumer prices. As shown, the increased market size permits the activity of more firms, increasing the number of varieties of the same product. Hence, consumers in a small closed economy will tend to pay more and have less variety of a product than consumers in a large closed economy.

Therefore, once the economies open up to international trade, the market size increases and both economies have access to the same number of varieties at the same price. It is noteworthy that, although being mutually beneficial, consumers in small economies benefit even more than consumers in large economies from opening up to trade.

As is standard in international trade theory everyone stands to gain from opening up to international trade. While that is true in equilibrium, the transition periods can tell a different story. Despite the fact that consumers in the small country are the ones who have more to gain from international trade, it is also the workers of the small country that have the most short-run loses. When we assume, as in the first model, that the whole cost structure is dependent on wages, then the efficiency downwards adjustment in wages (we have done it via exchange rate, but it could equally be done by nominal wage decreasing) is compensated by the decrease in prices, leaving real wages unaltered, just with the upside from the additional productivity coming from economies of scale. We observe that, even in a dynamic setting, worker's real wage could only increase by opening to international trade. But that is only true when there are only labor costs in the cost function.

When we consider that the cost structure of an industry also depends on factors that can not devalue via exchange rate, workers in firms that have a competitive disadvantage because of a low efficiency starting point (the smaller country in our model) might feel a negative impact during a transition period, losing purchasing power. While the country as a whole gains (specially those in non-tradable sectors that benefit from lower prices of tradable products), some agents within the country might have something to lose, at least in the short-run.

A flexible economy, allowing firms to adjust fast to the new reality, might significantly shorten in length this short-run loss. However, if the economy is too rigid and/or the initial efficiency differential is too large, the workers might lose purchasing power for a long period of time. International trade is a major driver of global growth and most nations, specially the smaller ones, have taken big jumps in productivity and welfare after getting more involved in international trade. However, political leaders need to ensure that economies are enough flexible to reduce transition times and that there are mechanisms in place to soften the short-run losses of those that pay the price of the international trade deals.

References

Appleyard, D.; Field, A.; Cobb, S. (2008) *International Economics*. New York, McGraw-Hill.

Caves, R.; Frankel, J.; Jones, R. (2007)*World Trade and Payments: An Introduction*, 10th Edition. New York, HarperCollins.

Balassa, B. (1967)*Trade Liberalization among Industrial Countries*. New York, McGraw-Hill.

Kravis, I. (1971)*The current case for import limitations*. In *Commission on International Trade and Investment Policy*, United States Economic Policy in an Interdependent World. Washington DC, U. S. Government Printing Office.

Krugman, P.; Obstfeld, M.(2006) *International Economics: Theory and Policy*, 6th Edition. New York, Harper Collins.

Krugman, P. (1979) Increasing Returns, Monopolistic Competition, and International Trade. *Journal of International Economics*, 9(4), 469-479.