Interest Rates and World Trade: An ‘Austrian’ Perspective*

Pol Antràs
Harvard University and NBER

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Abstract

This paper develops a framework to study the interplay between world trade and interest rates. The model incorporates an explicit notion of time and of production length, along the lines of the ‘Austrian’ tradition of Böhm-Bawerk (1889). Changes in the interest rate affect production lengths, labor productivity, and the financial costs of exporting. I decompose the response of the volume of world trade to changes in the interest rate into four components: (i) a labor productivity effect, (ii) a propensity to consume out of labor income effect, (iii) a temporal dimension of variable trade costs effect, and (iv) a selection into exporting effect.

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1 Introduction

The world economy witnessed a period of significant trade integration in the late 1980s, 1990s, and 2000s. This same period was accompanied by a substantial decline in real interest rates and, more broadly, by a decline in the cost of capital faced by firms (Barkai, 2020). Were these two phenomena unrelated? Or, perhaps, did the decline in the cost of capital partly fuel the growth in world trade? Answers to these questions are not only relevant for understanding past events, but they may also be informative in delineating possible scenarios for the future of world trade, particularly in current times in which inflationary pressures have led to much talk about interest rates continuing their recent upward trend over the next few years.

The international trade literature has extensively studied the causes and consequences of increased trade integration, but this literature is typically silent on the interplay between global trade and interest rates. This is not too surprising given that international trade models are, for the most part, static in nature.

This paper develops a framework to study the interplay between world trade and real interest rates. To do so, I build on the 'Austrian' model in Antràs (2023), which is in turn inspired by the work of Böhm-Bawerk (1889), Wicksell (1934), and Findlay (1978), among many others. The model incorporates an explicit notion of time and of production length: the time lag between the beginning of production and the delivery of goods to consumers is an endogenously determined outcome. Letting the production process mature for a longer period of time increases labor productivity, but it comes at the cost of higher working capital needs for firms. Selling to foreign markets provides an additional source of operating profits for firms, but these sales are associated with an additional time lag between production and consumption. Changes in the interest rate affect production lengths, labor productivity, and the financial costs of exporting, and thus the model is a suitable tool for studying the implications of changes in interest rates on world trade.

Although I borrow extensively from the framework in Antràs (2023), the model in the current paper is dramatically simpler in that I do *not* consider multi-stage production, which is a central aspect of the analysis in that previous paper. Conversely, in this paper I move beyond the constant-returns-to-scale and perfect competition assumptions in Antràs (2023), and I consider an environment with scale economies and imperfect competition. This allows me to better connect with current workhorse models in the international trade field, although I unapologetically restrict attention to special cases (such as focusing on trade integration between symmetric countries).

The main results of the paper gradually decompose the response of the volume of world trade to 'exogenous' changes in the interest rate into four components: (i) a labor productivity effect, (ii) a propensity to consume out of labor income effect, (iii) a temporal dimension of variable trade costs effect, and (iv) a selection into exporting effect.

2 Böhm-Bawerk Meets Krugman

There are three main building blocks to the theoretical framework. First, I introduce a model of international trade with product differentiation, scale economies, and monopolistic competition along the lines of the seminal work of Krugman (1980). Second, I incorporate a temporal dimension to production with its associated working capital needs in the 'Austrian' tradition of Böhm-Bawerk (1889), Wicksell (1934), Metzler (1950) and Findlay (1978), among many others. Finally, I close the model by incorporating a supply side to the capital market following Caballero et al. (2008). To build intuition, I develop the autarkic version of the model in this section, and later introduce global trade.

Time evolves continuously. Infinitesimal agents are born at a rate ρ per unit of time and die at the same rate; the population mass is therefore constant and equal to L. All agents are endowed with one unit of labor services which they supply inelastically to the market. Consumers value a final good which is costlessly put together by combining a continuum of differentiated varieties of intermediate inputs according to

$$U = Y = \left(\int_0^n \left(c_\omega\right)^{(\sigma-1)/\sigma} d\omega \right)^{\sigma/(\sigma-1)}, \tag{1}$$

where c_ω is the consumption of input variety ω, $\sigma > 1$ is the elasticity of substitution across varieties, and n is the available measure of varieties to be determined in equilibrium.

Input varieties are produced by a continuum of firms, each producing a single variety ω. The industry is monopolistically competitive, and there is free entry. Before any production takes place, firms need to incur a fixed overhead cost of f_e units of labor in order to be able to produce units of the inputs. This fixed cost can be interpreted as an entry cost (i.e., the cost of coming up with a differentiated variety). After this cost has been incurred, firms can produce units of the input variety with a linear technology in labor. We can succinctly express technology as

$$y_\omega = \varphi_\omega \left(L_\omega - f_e\right), \tag{2}$$

where φ_ω is inversely related to the marginal cost of production, and L_ω is the total amount of labor hired by the firm producing variety ω.

I incorporate an 'Austrian' dimension to the model by acknowledging that production *takes time*, and that the more time is devoted to production, the more output will be obtained. More specifically, I let labor productivity φ_ω be a function of time, or $\varphi_\omega(t)$. Firms hire an amount of labor L_ω at the beginning of production, and they could instantaneously produce an amount $\varphi_\omega(0)(L_\omega - f_e)$ of output. But by 'waiting' and letting the production process 'mature', labor efficiency increases as a function of time, though at a diminishing rate, or $\varphi'_\omega(t) > 0$ and $\varphi''_\omega(t)/\varphi'_\omega(t) < \varphi'_\omega(t)/\varphi_\omega(t)$. This assumption can be interpreted literally as workers improving their skills over time, or it could reflect the accumulation of some additional factor of production that enhances the productivity of labor. The assumption that labor is only paid at the very beginning of a stage's production is not important for the results below, but it simplifies the algebra.

Although lengthening the time taken to produce output enhances its efficiency, delaying production and sale comes at the cost of increasing the working capital needs of the firm, as firms need to borrow in order to cover the wage bill wL_ω. Given our continuous time environment, and letting the interest rate be given by r, the firm faces costs (inclusive of capital costs) equal to $wL_\omega e^{rt}$ after t periods.

I introduce a supply for capital into the model building on the work of Caballero et al. (2008). Remember that I have assumed that agents are born at a rate ρ per unit of time and die at the same rate. I now further assume that agents save all their income and consume the final good only when they (are about to) die. The parameter ρ is thus inversely related to the aggregate propensity to save of this economy, and therefore reflects the 'impatience' of agents. The final good is the only store of value in the economy: agents save accumulating claims on this good, which they can lend with interest to firms seeking to pay workers before selling their input varieties. Nevertheless, collecting interest demands that lenders incur monitoring costs m per unit of capital lent. In analogy to iceberg trade costs, I model these monitoring costs as 'melted' resources, and I interpret them as an inverse measure of financial development.

If K^s denotes aggregate savings (or capital), then aggregate consumption at any instant is ρK^s. In equilibrium, we must have income $wL + (r - m) K^s$ equal spending ρK^s and thus

$$K^s = \frac{wL}{\rho + m - r}. \tag{3}$$

The supply of capital is thus proportional to labor income, with the factor of proportionality being positively affected by the interest rate r and negatively affected by impatience ρ and by financial underdevelopment m.[1]

[1] I have focused on a stationary equilibrium with a constant capital stock. Following Caballero et al. (2008), it would be straightforward to allow new capital to be created one-to-one with the final good. Given an initial stock of capital K_0, equation (3) would then characterize capital supply in the steady state.

3 Closed-Economy Equilibrium

Because all firms face the same demand and have access to the same primitive technologies, I focus on a symmetric equilibrium in which all firms choose the same optimal production length t_ω and the same labor demand L_ω to maximize their (beginning of production) profits, which are given by

$$\max_{t_\omega, L_\omega} \pi = p_\omega \varphi_\omega (t_\omega)(L_\omega - f_e) e^{-rt_\omega} - wL_\omega,$$

with $p_\omega = A^{1/\sigma}(y_\omega)^{-1/\sigma}$, for some A that firms take as given. Following standard derivations, it is easy to solve for the optimal labor demand L_ω (or optimal firm-level output $y_\omega = \varphi_\omega(t_\omega)(L_\omega - f_e)$). This delivers an associated optimal price charged by producers given by

$$p_\omega = \frac{\sigma w e^{rt_\omega}}{(\sigma - 1)\varphi_\omega(t_\omega)}, \tag{4}$$

which constitutes a constant markup $\sigma/(\sigma - 1)$ over marginal cost, inclusive of cumulative interest.

The resulting optimal production length problem can thus be expressed as

$$\max_{t_\omega} \pi = \frac{1}{\sigma} A \left(\frac{\sigma w e^{rt_\omega}}{(\sigma - 1)\varphi_\omega(t_\omega)} \right)^{1-\sigma} e^{-rt_\omega} - wf_e.$$

Solving this problem, we can express the common optimal production length t^* for all firms as

$$\frac{\sigma - 1}{\sigma} \frac{\varphi'_\omega(t^*)}{\varphi_\omega(t^*)} = r. \tag{5}$$

This condition equates the marginal benefit of letting production mature to the marginal cost of waiting, which is related to the interest rate. The marginal benefit of lengthening production depends on the growth rate of labor productivity but also on the reciprocal of the markup charged by firms. Given the declining growth rate associated with $\varphi_\omega(t_\omega)$, the optimal length and labor productivity of all production processes is decreasing in the interest rate r and in the markup $\sigma/(\sigma - 1)$.

The fact that a high interest rate reduces the optimal production length is perfectly intuitive, but it may be more surprising to some readers that the optimal production length is independent of the parameters governing the scale of operation (A, w), and that it is decreasing in the markup charged by firms. The reason for these results is that the marginal benefit of letting production mature is associated with a reduction in marginal costs, while the marginal cost of letting production mature is associated with delaying the collection of revenue. Because production costs and revenue are proportional to each other, the choice is independent of scale, but a large ratio of revenue to costs (i.e., a higher markup) makes longer production chains less desirable.

Although the main results to be derived below should apply more generally, I will hereafter focus on a specific case in which labor productivity is given by

$$\varphi_\omega(t) = \varphi t^\zeta, \quad \zeta < 1, \tag{6}$$

where ζ is a measure of the time intensity of production, i.e., of the extent to which a longer maturation of the production process translates into higher labor productivity. With the specific functional form in (6), the optimal production length is simply given by

$$t^* = (\sigma - 1)\zeta/\sigma r, \tag{7}$$

and results in a level of labor productivity equal to

$$\varphi(t^*) = \left(\frac{(\sigma-1)\zeta}{\sigma r}\right)^\zeta \varphi. \tag{8}$$

A convenient feature of this log-linear case is that the cumulative interest e^{rt^*} is independent of the interest rate r, which will make this case particularly transparent in illustrating some of the main results below.

Having characterized firm behavior, we next turn to discussing the industry and general equilibrium of the model. Given the symmetry assumption, it is straightforward to invoke the zero-profit condition $p_\omega y_\omega e^{-rt} = wL_\omega$, together with labor-market clearing $L_\omega n = L$, to conclude that output per firm and the endogenous measure of firms are given by

$$y_\omega = Lc_\omega = (\sigma-1) f_e \varphi(t^*); \tag{9}$$

$$n = L/\sigma f_e, \tag{10}$$

just as in the original Krugman (1980) model. Note, however, that labor productivity $\varphi(t^*)$ is endogenous and shaped by the interest rate (see equation (8)). Thus, output per firm is higher in economies with lower interest rates.

To close the model in general equilibrium, I first set the final good as the numéraire. This implies $np^{1-\sigma} = 1$, and thus – invoking (4) and (10) – the equilibrium wage rate can be expressed as

$$w = \left(\frac{L}{\sigma f}\right)^{1/(\sigma-1)} \frac{\sigma-1}{\sigma}\varphi(t^*)\, e^{-(\sigma-1)\zeta/\sigma}. \tag{11}$$

Clearly, the wage rate w is decreasing in the interest rate r because $\varphi(t^*)$ in (8) is decreasing in r.

Finally, I consider a stationary equilibrium with a uniform time-invariant distribution of production processes at all possible levels of completion from 0 to t^*. This gives rise to an aggregate demand for capital equal to

$$K^d = \int_0^{t^*} wLe^{rt}dt = \frac{wL\left(e^{(\sigma-1)\zeta/\sigma}-1\right)}{r}, \tag{12}$$

where in the last equality I have invoked (6). Equating capital demand in (12) to capital supply in (3) delivers an equilibrium interest rate equal to

$$r = (\rho+m)\left(1-e^{-(\sigma-1)\zeta/\sigma}\right). \tag{13}$$

Naturally, the interest rate is higher, the higher the impatience of agents, and the higher are monitoring costs.

This completes the description of the closed-economy model.

4 Free Trade

I now consider a world equilibrium with two countries, Home and Foreign, symmetric in all aspects. Given the absence of trade costs, it should be clear that the equilibrium of this world economy is identical to that of the closed economy, except for the fact that population and the labor force are now $2 \times L$. Given the equilibrium equations above, it is then immediate that labor productivity, firm-level output and the interest rate will be *unaffected* by trade integration. Meanwhile, the number of available input varieties will double, and the real wage rate will increase by a factor of $2^{1/(\sigma-1)}$ in both countries.

It is also straightforward to compute the volume of world trade. At any instant, consumers in each country spend an amount $\rho K = wL + (r-m)K$ on the final good, and half of their spending is allocated to goods produced abroad. As a result, world exports (the sum of Home and Foreign exports) can be expressed as

$$T = 2 \times \frac{1}{2} \times \rho K = \frac{\rho}{\rho+m-r} \times wL,$$

where in the second equality I have invoked equation (3).

How is the volume of trade affected by 'exogenous' changes in the interest rate r? I study this question by considering an increase in financial development, i.e., a reduction in m. From the capital-market equilibrium, the fall in m reduces the interest rate r. This in turn increases the production length t^*, labor productivity $\varphi(t^*)$, and the wage rate w. Because equation

(13) implies $r'(m) < 1$, $m - r$ necessarily falls in m, and thus the ratio of spending to labor income $\rho/(\rho + m - r)$ also rises when m falls, which further boosts world trade. Intuitively, lower monitoring costs raise the supply of working capital, and consumption thereby increases. Such an 'exogenous' change in the interest rate thus leads to a rise in world trade by increasing both labor productivity and wages as well as the propensity to consume out of labor income.

A reduction in ρ, perhaps reflecting a 'savings glut', also reduces the interest rate, thereby increasing t^* and w, as well as the supply of capital. Nevertheless, the fall in ρ also has a direct negative effect on the propensity to consume out of labor income, and one can show that $\rho/(\rho + m - r)$ actually *increases* in ρ. This is intuitive: if the reduction in interest rates is due to an increase in the propensity to save, this will tend to depress consumption and thus world trade. The overall effect of changes in ρ on world trade is thus ambiguous.

5 Costly Trade

Consider next a situation in which, relative to domestic transactions, shipping goods across borders involves an additional interval of time d between the time at which production is completed and the time at which the shipment is received. It would be straightforward to add an atemporal iceberg trade cost τ (reflecting shipping fees, insurance, etc.), but this is not essential for the results below.

The problem a representative Home firm solves is now

$$\max_{t_\omega, \ell_\omega^h, \ell_\omega^x} \pi = p_\omega^h \varphi_\omega (t_\omega) \ell_\omega^h e^{-rt_\omega} + p_\omega^x \varphi_\omega (t_\omega) \ell_\omega^x e^{-r(t_\omega + d)} - wL_\omega,$$

where the superscript h is used for variables associated with domestic transactions and the superscript x is used for variables related to foreign transactions. The terms ℓ_ω^h and ℓ_ω^x are the amounts of labor hired in variable costs, with $L_\omega = \ell_\omega^h + \ell_\omega^x + f_e$. Solving for the optimal labor demands ℓ_ω^h and ℓ_ω^x allows us to express the optimal production length problem as:

$$\max_{t_\omega} \pi = \frac{1}{\sigma} A \left(1 + e^{-rd\sigma}\right) \left(\frac{\sigma w e^{rt_\omega}}{(\sigma - 1)\varphi(t_\omega)}\right)^{1-\sigma} e^{-rt_\omega} - wf_e.$$

Simple differentiation then results in an optimal production length t^* common for all firms and given by the same equation (5) applying in the closed-economy model. Intuitively, and as explained above, the optimal production length is independent of scale whenever the markup charged by firms is independent of scale as well.

Denoting domestic and exported output as $y_\omega^h = \ell_\omega^h/\varphi_\omega(t_\omega)$ and $y_\omega^x = \ell_\omega^x/\varphi_\omega(t_\omega)$, respectively, it is easy to verify that the free-entry and labor-market clearing conditions result in

$$\begin{aligned} y_\omega^h + y_\omega^x &= (\sigma - 1) f_e \varphi(t^*); \\ n &= L/\sigma f_e. \end{aligned}$$

Firm-level output and the number of varieties produced by firms in each country is thus unaffected by the level of trade costs.

On the other hand, the wage rate and the interest rate *are* shaped by the level of trade costs. Setting the price of the final good as the numéraire results in $n\left(p^h\right)^{1-\sigma} + n\left(p^x\right)^{1-\sigma} = 1$, and thus the wage rate can be expressed as

$$w = \left(\frac{L}{\sigma f_e}\left(1 + e^{-rd(\sigma-1)}\right)\right)^{1/(\sigma-1)} \frac{\sigma - 1}{\sigma} \varphi(t^*)\, e^{-(\sigma-1)\zeta/\sigma}. \tag{14}$$

Holding the interest rate fixed, the (real) wage rate is thus a monotonically decreasing function of trade costs d. In addition, the wage rate continues to be a decreasing function of the interest rate r, both on account of the term $\varphi(t^*)$, but now also on account of the term $e^{-rd(\sigma-1)}$.

In order to solve for the equilibrium interest rate, first note that capital demand now includes a new term reflecting the financing needs of firms associated with the shipping lag d. In Appendix A.1, I show that this delivers a demand for capital equal to

$$K^d = \frac{wL}{r}\left(e^{(\sigma-1)\zeta/\sigma} - 1 + e^{(\sigma-1)\zeta/\sigma}\frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1}\right). \tag{15}$$

In Appendix A.1, I also show that K^d/wL continues to be a declining function of r, which together with the upward sloping capital supply schedule in (3), ensures the existence of a unique interest rate that clears the capital market.

Comparing this equation to (12), it is also clear that the ratio K^d/wL is higher with costly trade ($d > 0$) than under autarky or under free trade ($d = 0$). Intuitively, the temporal dimension of trade costs is now associated with a new source of working capital needs. Because the ratio of capital supply to the wage bill (K^s/wL) is independent of trade costs d, it then follows that the interest rate is necessarily *higher* with costly trade than under autarky or free trade. For $\sigma > 2$, which is a necessary condition for (15) to converge to (12) when $d \to \infty$, the interest rate is a non-monotonic function of distance, increasing in trade costs for low d, but decreasing in trade costs for large enough d. This result raises the intriguing possibility that part of the decline in interest rates in the 1980s, 1990s, and 2000s may have been explained by a reduction in the financial needs of globally engaged firms driven by technological developments (such as the increased use of air shipping, or the adoption of just-in-time inventory methods) that reduced the time lag between production and delivery.

Using the fact that the relative demand for foreign and domestic varieties must satisfy $p^x y^x / p^h y^h = \left(p^x/p^h\right)^{1-\sigma} = e^{-rd(\sigma-1)}$, we can finally solve for the volume of world trade as

$$T = \frac{2e^{-rd(\sigma-1)}}{1+e^{-rd(\sigma-1)}} \times \frac{\rho}{\rho+m-r} \times wL. \tag{16}$$

'Exogenous' decreases in the interest rate driven by a reduction in m affect world trade via the same two mechanisms as in the free trade case, namely by increasing labor productivity and wages (see equation (14)), and by increasing the propensity to consume out of labor income.[2] But costly trade introduces a third mechanism, captured by the term $e^{-rd(\sigma-1)}$, by which low interest rates boost world trade. In words, due to the temporal dimension of trade costs, lower interest rates lead to endogenously lower trade costs, which foster deeper trade integration.[3]

6 Böhm-Bawerk Meets Melitz

I finally expand the model to an environment with firm heterogeneity and fixed costs of exporting, as in Melitz (2003). In particular, I now assume that, upon paying the fixed cost of entry f_e, firms draw a core productivity level φ from some distribution $G(\varphi)$. Firms then decide whether to exit, produce only for the domestic market (with additional overhead cost f_h) or produce for both the domestic and foreign markets (with a total overhead cost of $f_h + f_x$). Firms also choose their optimal production length, but given our discussion above, it should be clear that because all firms charge the same markup, they will also choose a common production length t^*. With the functional form in (6), we have $\varphi_\omega(t^*) = (t^*)^\zeta \varphi$, with t^* given in equation (7).

Following analogous steps as in previous sections, it is straightforward to show that firms producing only for the domestic market obtain operating profits equal to

$$\pi_h(\varphi) = \frac{1}{\sigma} A \left(\frac{\sigma w e^{(\sigma-1)\zeta/\sigma}}{(\sigma-1)\varphi_\omega(t^*)} \right)^{1-\sigma} e^{-(\sigma-1)\zeta/\sigma} - w f_h,$$

while exporters obtain an additional operating profit of

$$\pi_x(\varphi) = \frac{1}{\sigma} A \left(\frac{\sigma w e^{(\sigma-1)\zeta/\sigma} e^{rd}}{(\sigma-1)\varphi_\omega(t^*)} \right)^{1-\sigma} e^{-(\sigma-1)\zeta/\sigma} e^{-rd} - w f_x.$$

We can thus solve for two thresholds φ_h and φ_x such that all firms with productivity $\varphi < \varphi_h$ exit upon observing their core productivity φ, all firms with productivity $\varphi \in [\varphi_h, \varphi_x]$ sell only

[2]It can be shown that for reductions in m to decrease $m - r$ (and thus increase the ratio $\rho/(\rho - m)$), it is sufficient that the ratio K^d/wL decreases in r, which I have shown to be the case in Appendix A.1.

[3]With costly trade, reductions in ρ continue to have ambiguous effects on world trade. In fact, with costly trade, it is no longer unambiguous that a reduction in ρ decreases $\rho/(\rho + m - r)$.

in their domestic market, and all firms with $\varphi > \varphi_x$ additionally export to the foreign market.[4] These thresholds are defined by $\pi_h(\varphi_h) = 0$ and $\pi_x(\varphi_x) = 0$, respectively, and thus satisfy

$$\left(\frac{\varphi_x}{\varphi_h}\right)^{\sigma-1} = e^{rd(\sigma-1)} \times \frac{f_x e^{rd}}{f_h}. \tag{17}$$

The first term in the right-hand-side of (17) reflects the relative disadvantage faced by firms when selling in foreign markets due to the time lag d between shipment and delivery. This term was already present in the costly trade version of the model in the last section. The second term governs the relative size of the overhead costs of selling domestically and internationally. Note that the foreign fixed cost is magnified by a factor e^{rd} because the temporal dimension of international shipping leads to larger working capital needs associated with the exporting fixed cost f_x relative to the working capital needs associated with the domestic fixed cost f_h. This second term thus introduces a new channel via which changes in interest rates may shape world trade flows.

To see this more formally, note that we can express world trade as

$$T = 2 \times \frac{\int_{\varphi_x}^{\infty} p^x(\varphi)\, y^x(\varphi)\, dG(\varphi)}{\int_{\varphi_h}^{\infty} p^h(\varphi)\, y^h(\varphi)\, dG(\varphi) + \int_{\varphi_x}^{\infty} p^x(\varphi)\, y^x(\varphi)\, dG(\varphi)} \times \frac{\rho}{\rho + m - r} \times wL, \tag{18}$$

which after a few simple manipulations (see Appendix A.3) can be expressed similarly to Helpman et al. (2008) as

$$T = 2 \times \frac{e^{-rd(\sigma-1)} \times V(\varphi_x)/V(\varphi_h)}{1 + e^{-rd(\sigma-1)} \times V(\varphi_x)/V(\varphi_h)} \times \frac{\rho}{\rho + m - r} \times wL,$$

where

$$V(\varphi_j) = \int_{\varphi_j}^{\infty} \varphi^{\sigma-1} dG(\varphi) \quad \text{for } j = h, x.$$

This expression is analogous to (16), except for the additional term $V(\varphi_x)/V(\varphi_h) < 1$. This term is decreasing in φ_x and increasing in φ_h, and in the often-used case in which $G(\varphi)$ is a Pareto distribution, the term reduces to

$$V(\varphi_x)/V(\varphi_h) = (\varphi_x/\varphi_h)^{-(\kappa-(\sigma-1))},$$

where $\kappa > \sigma - 1$ is the shape parameter of the Pareto distribution. As derived above in equation (17), φ_x/φ_h is not only increasing in f_x and decreasing in f_h, but it also increases with the interest rate r. As a result, lower interest rates foster selection into exporting, and thus further

[4] To ensure that $\varphi_x > \varphi_h$, we must assume that $e^{rd\sigma} f_x > f_h$ (see equation (17)).

boost world trade. To see this more formally, we can express world trade in (18) as

$$T = 2 \times \frac{\left(\frac{f_x e^{rd}}{f_h}\right)^{\frac{-\kappa}{\sigma-1}} \times e^{-rd\kappa}}{1 + \left(\frac{f_x e^{rd}}{f_h}\right)^{\frac{-\kappa}{\sigma-1}} \times e^{-rd\kappa}} \times \frac{\rho}{\rho + m - r} \times wL. \tag{19}$$

This expression makes explicit this fourth mechanism by which the interest rate affects world trade. Beyond increasing labor income and the ratio of spending to labor income (the last two terms in (19)), and beyond endogenously reducing variable trade costs (the term $e^{-rd\kappa}$), a lower interest rate now further fosters selection into exporting by reducing the capital costs associated with the fixed cost of exporting f_x. This last effect is captured by the term $\left(e^{rd}\right)^{-\kappa/\sigma-1}$ in equation (19).[5]

7 Conclusions

In this paper, I have studied the implications of changes in interest rates for world trade. I have done so by developing a stylized 'Austrian' model of international trade, in which low interest rates facilitate the sustainability of more 'roundabout' production processes that result in higher labor productivity, higher income, and higher world trade. By incorporating an explicit notion of time, the framework also formalizes how low interest rates reduce the working capital needs for international transactions, which typically involve a disproportionately high time lag between production and consumption. By endogenously reducing trade costs, lower interest rates further boost world trade. The results in this paper suggest that if interest rates continue to rise over the next few years, they could contribute to a deceleration in the growth of world trade.

[5] Admittedly, I have not formally shown that wages and the propensity to consume $\rho/\left(\rho + m - r\right)$ are decreasing in the interest rate. For reductions in m to increase $\rho/\left(\rho + m - r\right)$, it will again suffice that the demand for capital is downward sloping (which ensures that $r'\left(m\right) < 1$). The fact that wages are decreasing in the interest rate can be shown by solving for the ideal price index following the same steps as in Melitz (2003).

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A Appendix

A.1 Capital Demand with Costly Trade

Note that capital is demanded by firms to cover the wage bill associated with both domestic sales and exports. After t^* 'periods', the firm collects revenue equal to $p^h y^h$, and after $t^* + d$ periods, it collects revenue equal to $p^x y^x$. Given free entry, it seems natural to assume that the firm will pay a share $p^h y^h / \left(p^x y^x + p^h y^h\right)$ of its wage bill after t^* periods, and the rest after $t^* + d$ periods. Under this assumption, in a stationary equilibrium with a uniform time-invariant distribution of production processes at all possible levels of completion, capital demand is given by

$$K^d = \int_0^{t^*} \frac{p^h y^h}{p^x y^x + p^h y^h} wLe^{rt} dt + \int_0^{t^*+d} \frac{p^x y^x}{p^x y^x + p^h y^h} wLe^{rt} dt.$$

Using the fact that $p^x y^x / p^h y^h = \left(p^x / p^h\right)^{1-\sigma} = e^{-rd(\sigma-1)}$, we can then write

$$K^d = \int_0^{t^*} \frac{1}{1 + e^{-rd(\sigma-1)}} wLe^{rt} dt + \int_0^{t^*+d} \frac{e^{-rd(\sigma-1)}}{1 + e^{-rd(\sigma-1)}} wLe^{rt} dt,$$

which can be expressed, after some simple manipulations, as

$$K^d = \frac{wL}{r} \left(e^{(\sigma-1)\zeta/\sigma} - 1 + e^{(\sigma-1)\zeta/\sigma} \frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1} \right),$$

as claimed in the main text.

I next show that K^d/wL is a decreasing function of the interest rate r. I focus on the case $\sigma \geqslant 2$ because this is a necessary condition for K^d/wL to converge to its autarky level when $d \to \infty$. Note first that we can write

$$\frac{K^d}{wL} = \left(\frac{e^{(\sigma-1)\zeta/\sigma} - 1}{r} \right) + \frac{e^{(\sigma-1)\zeta/\sigma}}{r} \frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1},$$

where the first term is K^d/wL under autarky (or free trade), and is obviously decreasing in r. We can thus focus on the term

$$\Omega(r) = \frac{1}{r} \frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1}.$$

Simple differentiation indicates that

$$\Omega'(r) = \frac{-1}{r^2} \frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1} + \frac{1}{r} \frac{de^{rd}\left(e^{rd(\sigma-1)} + 1\right) - \left(e^{rd} - 1\right) d(\sigma-1) e^{rd(\sigma-1)}}{\left(e^{rd(\sigma-1)} + 1\right)^2},$$

which is negative if and only if

$$\left(e^{rd}-1\right)\left(e^{rd(\sigma-1)}+1\right) > rde^{rd}\left(e^{rd(\sigma-1)}+1\right)-\left(e^{rd}-1\right)rd\left(\sigma-1\right)e^{rd(\sigma-1)}.$$

After a couple of simple manipulations, this condition can be expressed as

$$1+\frac{rd\left(\sigma-1\right)e^{rd(\sigma-1)}}{e^{rd(\sigma-1)}+1} > \frac{rde^{rd}}{e^{rd}-1}.$$

To show that this inequality indeed holds for all $r>0$ and $d\geqslant 0$, consider the function

$$f\left(x\right)=\frac{xe^{x}}{e^{x}+1}.$$

It is straightforward to verify that $f'\left(x\right)>0$ for $x>0$, since both x and $e^{x}/\left(e^{x}+1\right)$ are positive and increasing in x. Thus, for $\sigma\geqslant 2$, we necessarily have

$$1+\frac{rd\left(\sigma-1\right)e^{rd(\sigma-1)}}{e^{rd(\sigma-1)}+1} > 1+\frac{rde^{rd}}{e^{rd}+1},$$

and what remains to show then is that

$$1+\frac{rde^{rd}}{e^{rd}+1} > \frac{rde^{rd}}{e^{rd}-1}.$$

This inequality can alternatively be expressed as

$$e^{2rd}-2rde^{rd}>1.$$

But this inequality necessarily holds because

$$g\left(x\right)=e^{2x}-2xe^{x}$$

is increasing in x and takes a value of 1 when $x=0$.[6]

In sum, $\Omega'\left(r\right)<0$ and thus the ratio K^{d}/wL is decreasing in r for $\sigma\geqslant 2$.

A.2 Ratio of Spending to Labor Income

Remember that the ratio of spending to labor income is given by

$$\Lambda=\frac{\rho}{\rho+m-r}.$$

[6] Note that $g'\left(x\right)=2e^{x}\left(e^{x}-1-x\right)\geqslant 0$, where the inequality follows from $e^{x}-x$ being increasing in x and equal to 1 when $x=0$.

How do decreases in m affect this term, taking into account the effect of this parameter on the interest rate? In the case with free trade, it straightforward to see that the overall effect of a decrease in m is to increase Λ, even though this same change is associated with a decrease in the interest rate (a change that *per se* reduces Λ). Specifically, we have

$$r = (\rho + m)\left(1 - e^{-(\sigma-1)\zeta/\sigma}\right),$$

and thus

$$\Lambda = \frac{\rho}{\rho + m} e^{(\sigma-1)\zeta/\sigma},$$

which clearly decreases in m.

In the case of costly trade, the equilibrium interest rate is implicitly defined by the equality of capital demand in (15) and capital supply in (3), which delivers

$$\frac{1}{r}\left(e^{(\sigma-1)\zeta/\sigma} - 1 + e^{(\sigma-1)\zeta/\sigma}\frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1}\right) = \frac{1}{\rho + m - r}.$$

Next define

$$\phi(r) = e^{(\sigma-1)\zeta/\sigma} - 1 + e^{(\sigma-1)\zeta/\sigma}\frac{e^{rd} - 1}{e^{rd(\sigma-1)} + 1},$$

so we can write

$$\frac{\phi(r)}{r} = \frac{1}{\rho + m - r}, \tag{A.1}$$

or

$$r = (\rho + m)\frac{\phi(r)}{1 + \phi(r)}. \tag{A.2}$$

Remember that I have shown in Appendix A.1 that $K^d/wL = \phi(r)/r$ is decreasing in r. Given equation (A.1), this in turn implies that r is monotonically increasing in m, just as in the free trade case. Furthermore, totally differentiating (A.2), we obtain

$$dr = \frac{\phi(r)}{1 + \phi(r)}dm + (\rho + m)\frac{\phi'(r)}{(1 + \phi(r))^2}dr,$$

which can be re-arranged as

$$\frac{dr}{dm} = \frac{\phi(r)}{\phi(r) + 1 - \frac{r\phi'(r)}{\phi(r)}} < 1. \tag{A.3}$$

The inequality follows from the fact that $\phi'(r)\,r/\phi(r) < 1$ whenever $K^d/wL = \phi(r)/r$ is decreasing in r.

Note next that we can write Λ as

$$\Lambda = \frac{\rho}{\rho + m}(1 + \phi(r)),$$

and the fact that this decreases in m follows from:

$$\begin{aligned}
\frac{d\Lambda}{dm} &= \rho \frac{\phi'(r)\frac{dr}{dm}(\rho+m)-(1+\phi(r))}{(\rho+m)^2} \\
&= \frac{\rho}{(\rho+m)^2}(1+\phi(r))\left(\frac{\phi'(r)\,r}{\phi(r)}\frac{dr}{dm}-1\right)<0,
\end{aligned}$$

where the inequality follows from $\phi'(r)\,r/\phi(r)<1$ and $dr/dm<1$.

A.3 World Trade Flows with Firm Heterogeneity

As claimed in equation (18), world trade flows are

$$T=\frac{2\int_{\varphi_x}^{\infty}p^x(\varphi)\,y^x(\varphi)\,dG(\varphi)}{\int_{\varphi_h}^{\infty}p^h(\varphi)\,y^h(\varphi)\,dG(\varphi)+\int_{\varphi_x}^{\infty}p^x(\varphi)\,y^x(\varphi)\,dG(\varphi)}\frac{\rho}{\rho+m-r}wL.$$

Next note that

$$p^h(\varphi)\,y^h(\varphi)=A\left(\frac{\sigma w e^{(\sigma-1)\zeta/\sigma}}{(\sigma-1)\,\varphi_\omega(t^*)}\right)^{1-\sigma},$$

while

$$p^x(\varphi)\,y^x(\varphi)=A\left(\frac{\sigma w e^{(\sigma-1)\zeta/\sigma}e^{rd}}{(\sigma-1)\,\varphi_\omega(t^*)}\right)^{1-\sigma}.$$

We thus have that

$$\begin{aligned}
T &= \frac{2e^{-rd(\sigma-1)}\int_{\varphi_x}^{\infty}\varphi^{\sigma-1}dG(\varphi)}{\int_{\varphi_h}^{\infty}\varphi^{\sigma-1}dG(\varphi)+e^{-rd(\sigma-1)}\int_{\varphi_x}^{\infty}\varphi^{\sigma-1}dG(\varphi)}\frac{\rho}{\rho+m-r}wL \\
&= \frac{2e^{-rd(\sigma-1)}V(\varphi_x)/V(\varphi_h)}{1+e^{-rd(\sigma-1)}V(\varphi_x)/V(\varphi_h)}\frac{\rho}{\rho+m-r}wL,
\end{aligned}$$

as claimed in the main text.

Whenever φ is Pareto distributed with shape parameter $\kappa>\sigma-1$, we have

$$\frac{V(\varphi_x)}{V(\varphi_h)}=\frac{\int_{\varphi_x}^{\infty}\varphi^{\sigma-1}\varphi^{-\kappa-1}d\varphi}{\int_{\varphi_h}^{\infty}\varphi^{\sigma-1}\varphi^{-\kappa-1}d\varphi}=\left(\frac{\varphi_x}{\varphi_h}\right)^{-(\kappa-(\sigma-1))},$$

as claimed in the main text.