An 'Austrian' Model of Global Value Chains

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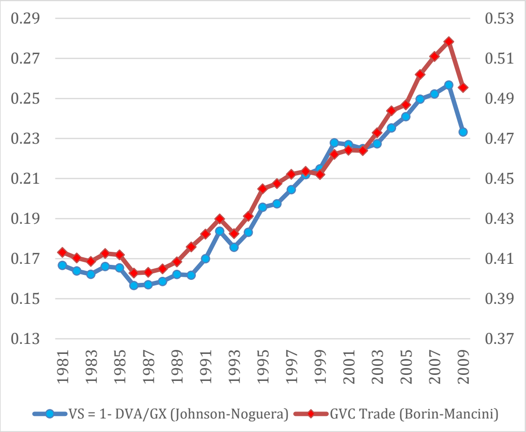
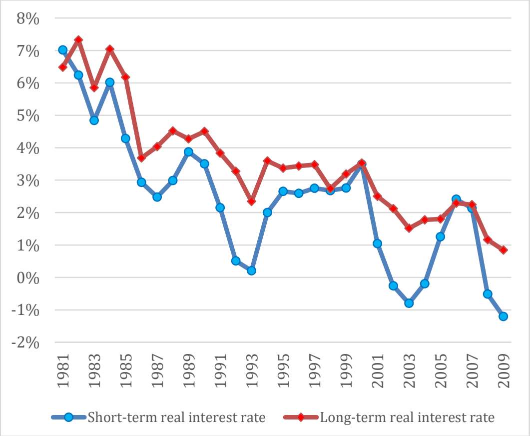
Two Salient Trends in World Economy



Rising GVC Participation



Declining Real Interest Rates

A Link? Potential Mechanism

- Is the observed decline in real interest rates partly responsible for the growth in GVCs?
- Potential mechanism: low interest rates facilitate the sustainability of *longer* production processes
  - firms can better allocate worldwide resources to their more efficient use, with less regard to the time it takes to combine these worldwide resources
  - this generates more within-production process specialization, and thus more 'GVC' trade
- Formalizing this hypothesis is not straightforward. It requires:
  - developing a framework with an explicit notion of production length and of delivery time
  - modeling trade costs in a framework with sequential production
- I build an 'Austrian' model of GVCs à la Böhm-Bawerk (1889), Wicksell (1934), and Findlay (1978), and study trade costs à la Antràs and de Gortari (2020)

Goals of the Paper

- I develop a stylized model of sequential production with N stages in which the time length of each stage is endogenously determined
- Letting the production process *mature* increases labor productivity, but it comes at the cost of higher working capital needs for firms
- I study autarky, free trade and costly trade equilibria
- Some issues the model might be particularly suitable to shed light on:
  1. Does it matter how capital is conceptualized? Clark (1888) vs. Böhm-Bawerk (1889)
  2. What are the implications of the temporal dimension of trade costs, and how are they are shaped by interest rates?
  3. What are the roles and effects of trade credit and trade finance?
- Let me defer the discussion of the main results

Literature Review

- 'Austrian' concept of capital
  - Jevons (1871), Böhm-Bawerk (1889), Wicksell (1934), Metzler (1950), **Findlay (1978)**
- Sequential GVCs
  - Dixit and Grossman (1982), Sanyal and Jones (1982), Yi (2003, 2010), Harms et al. (2012), Antràs and Chor (2013), Costinot et al. (2013), Baldwin and Venables (2018), Kikuchi et al. (2018), Alfaro et al. (2019), Johnson and Moxnes (2019), Antràs and de Gortari (2020), Tyazhelnikov (2022)
- GVCs and Capital: Sposi et al. (2021), Ding (2022); Kim and Shin (2012, 2017)
- Trade and Time: Deardorff (2003), Evans and Harrigan (2005), Djankov et al. (2010), Hummels and Schaur (2013)
- Inventories, Just-in-Time: Alessandria et al. (2011), Ferrari (2022), Pisch (2022), Carreras-Valle (2022)

Closed-Economy Model

Closed-Economy Model: Environment

- Time evolves continuously
- Infinitesimal agents are born at a rate ρ per unit of time and die at the same rate; population mass is 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 single final good, which it is taken to be the numéraire
- Production technologies (see next slide) are freely available to all agents in the economy, and perfect competition prevails in all markets
- For now, I assume that capital markets are perfectly functioning, so agents borrow and lend at interest rate r

Closed-Economy Model: Multi-Stage Production

- Production of the final good needs to undergo N stages in a pre-determined order
- At each stage $n > 1$, production combines labor with the good finished up to $n - 1$
- Production in the initial stage $n = 1$ only uses labor
- Production technologies in all sectors are homogeneous of degree one
- I will restrict the analysis to Cobb-Douglas production technologies at all stages $n > 1$:

$$y_n = (z_n L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n}$$

- z_n denotes labor productivity at stage n, and $\alpha_n \in [0, 1]$ is value-added-intensity at n
- Final output is $y_N = \prod_{n=1}^{N} (z_n (t_n) L_n)^{\alpha_n \beta_n}$, with $\beta_n \equiv \prod_{m=n+1}^{N} (1 - \alpha_m)$

Closed-Economy Model: Optimal Production Length

- Production *takes time*: the more time is spent on production, the more output is obtained
  - I formalize this in an 'Austrian' manner following the approach in Findlay (1978)

- Consider stage n: firms initially hire an amount L_n of labor, and could instantaneously produce an amount $y_n = (z_n(0) L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n}$ of stage-n output

- But by 'waiting' and letting the production process 'mature', labor efficiency increases as a function of time, though at a diminishing rate (wood/wine metaphors)
  - $z_n'(t) > 0$ and $z_n''(t)/z_n'(t) < 0 < z_n'(t)/z_n(t)$

- Lengthening production and delaying sales comes at cost of higher working capital needs

- Producers maximize their profits:

$$\pi_n = p_n (z_n(t_n) L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n} e^{-rt_n} - wL_n - p_{n-1} y_{n-1}$$

Closed-Economy Model: Optimal Production Length

- The optimal stopping (or 'chopping' off) time t_n^* satisfies:

$$\alpha_n \frac{z_n'\left(t_n^*\right)}{z_n\left(t_n^*\right)} = r$$

- The length and labor productivity of all production processes are decreasing in r
- Log-linear case: when $z_n\left(t_n\right) = \left(t_n\right)^{\zeta_n}$, we have $t_n^* = \alpha_n \zeta_n / r$
  - The optimal length t_n^* of a given stage is increasing in the value-added intensity α_n and time intensity ζ_n of stage n, and decreasing in the interest rate r
  - But rt_n^* is independent of the interest rate r (very helpful!)
- I obtain same results when solving the *lead-firm* problem (Antràs and de Gortari, 2020)

Closed-Economy Model: Equilibrium in the Labor Market

$$L_n = \frac{\alpha_n \beta_n e^{-r \sum_{m=n}^{N} t_m^*}}{\sum_{n'=1}^{N} \alpha_{n'} \beta_{n'} e^{-r \sum_{m=n'}^{N} t_m^*}} L$$

- More labor is allocated to relatively more important stages of production (high $\alpha_n \beta_n$) and also to relatively downstream stages (due to lower working capital needs)

$$w = \prod_{n=1}^{N} \left(\alpha_n \beta_n z_n \left(t_n^* \right) e^{-r \sum_{m=n}^{N} t_m^*} \right)^{\alpha_n \beta_n}$$

- Envelope theorem implies that the lower is the interest rate r, the higher is the wage w

Closed-Economy Model: Demand for Capital

- **Cumulated** working capital needs associated with stage-n labor costs are given by

$$e^{r\sum\limits_{m=n}^{N} t_m^*} wL_n$$

- In a stationary equilibrium with a time-invariant distribution of production processes of different ages, we have

$$K^d = \sum_{n=1}^{N} wL_n \int_0^{\sum_{m=n}^{N} t_m^*} e^{rt} dt = \sum_{n=1}^{N} wL_n \frac{e^{r\sum\limits_{m=n}^{N} t_m^*} - 1}{r}$$

- Aggregate capital demand typically falls in interest rate r (certainly in log-linear case)
- Invoking the zero-profit condition at all stages, we obtain

$$y_N = \sum_{n=1}^{N} wL_n e^{r\left(\sum\limits_{m=n}^{N} t_m\right)} = wL + rK^d$$

Closed-Economy Model: Supply of Capital and Capital-Market Equilibrium

- Supply of capital modeled as in Antràs and Caballero (2009, 2010)
  - Final good is only store of value
  - Agents save their income and consume right before dying (ρ governs impatience)

- Supply of capital at any point in time is proportional to labor income

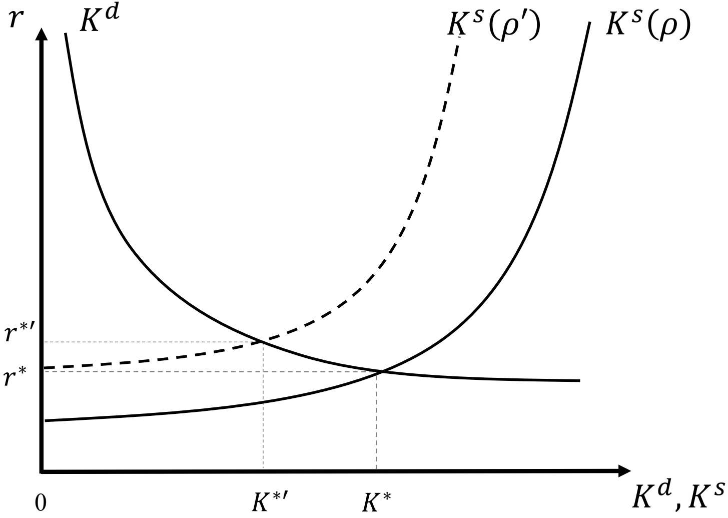
$$K^s = wL \times \sigma(r, \rho),$$

with $\sigma = 1/(\rho - r)$ increasing in r and decreasing in ρ

- Equilibrium interest rate pinned down à la Metzler (1951)

$$\frac{K^d}{wL} = \sum_{n=1}^{N} \frac{L_n}{L} \frac{e^{r\left(\sum_{m=n}^{N} t_m^*\right)} - 1}{r} = \sigma(r, \rho) = \frac{K^s}{wL}$$

Equilibrium in the Capital Market



Open-Economy Model

Open-Economy Model: Environment

- Consider a world economy in which two economies (H, F) engage in international trade
- I make a number of simplifying assumptions:
  - Countries are symmetric in all respects except for the 'impatience' of their agents (Home is more patient)
  - All production technologies and all functions $z_n(t_n)$ are common in both countries
  - I mostly focus attention on log-linear case with $z_n(t_n) = (t_n)^{\zeta_n}$
  - I abstract (for now) from trade costs
  - I rule out (for now) international borrowing or lending, or international trade credit/finance
- Under autarky, interest rate is lower ($r^H < r^F$) and wage is higher ($w^H > w^F$) at Home
- For now, I impose that factor price differences remain true under free trade

Comparative Advantage

- It may seem intuitive that the more patient Home would have a comparative advantage in relatively upstream stages of production
  - Cumulative interest until final consumption is higher for those stages
  - Indeed, a key result in Findlay (1978) is that the more patient country specializes upstream
- **WRONG!**
- No reason to wait to be paid until final good is completed and sold to consumers
- What if producers at n are paid right after producing by $n-1$ producers?
- This is actually implied by no international borrowing and lending when n and $n+1$ are produced in different countries

Comparative Advantage

- Ratio of Home to Foreign prices at stage n is given by

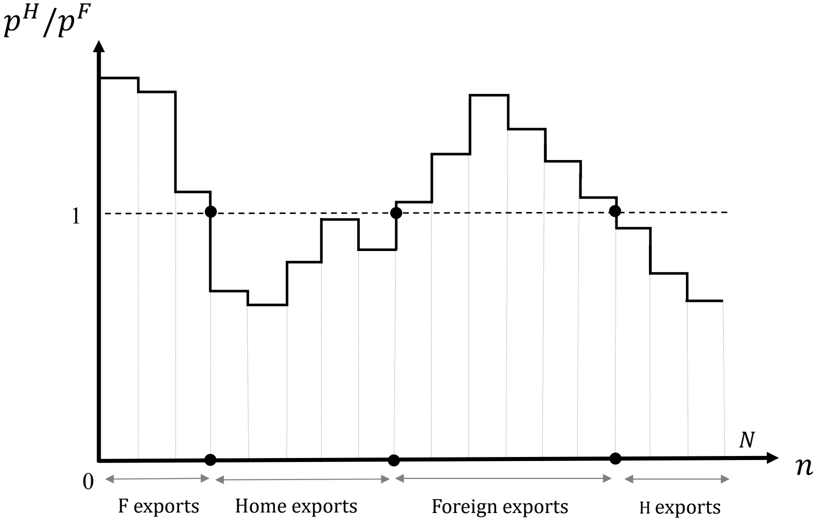
$$\frac{p_n^H}{p_n^F} = \left(\frac{w^H}{w^F} \frac{z_n\left(t_n^F\right)}{z_n\left(t_n^H\right)} \frac{e^{r^H t_n^H}}{e^{r^F t_n^F}} \right)^{\alpha_n} \left(\frac{p_{n-1}}{p_{n-1}} \frac{e^{r^H t_n^H}}{e^{r^F t_n^F}} \right)^{1-\alpha_n}$$

- In the log-linear case $\left(z_n\left(t_n\right) = \left(t_n\right)^{\zeta_n}\right)$ this reduces to

$$\frac{p_n^H}{p_n^F} = \left(\frac{w^H}{w^F} \left(\frac{r^H}{r^F} \right)^{\zeta_n} \right)^{\alpha_n}$$

- Comparative advantage is shaped by the relative size of the parameter ζ_n across stages
- So what matters is **relative time intensity**, not relative upstreamness

Comparative Advantage and Downstreamness



Trade Equilibrium with Factor Price Differences

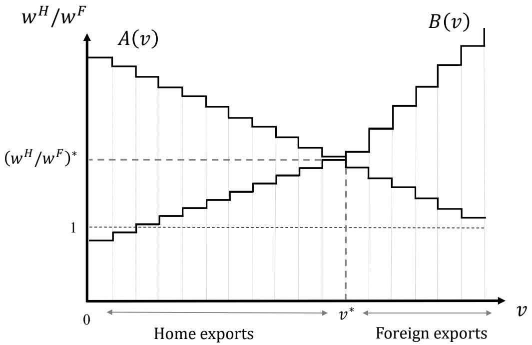
- Assume we can partition the set of stages into two disjoint sets $\mathcal{N}^H$ and $\mathcal{N}^F$, with $\mathcal{N}^j$ being the set of stages in which country $j = H, F$ has comparative advantage
- Let us next reorder stages in decreasing order of their time intensity ζ_n (using index v)
- Define the relative labor efficiency schedule

$$A(v) \equiv \frac{z_n\left(t_n^H\right)}{z_n\left(t_n^F\right)} = \left(\frac{r^F}{r^H}\right)^{\zeta_v}$$

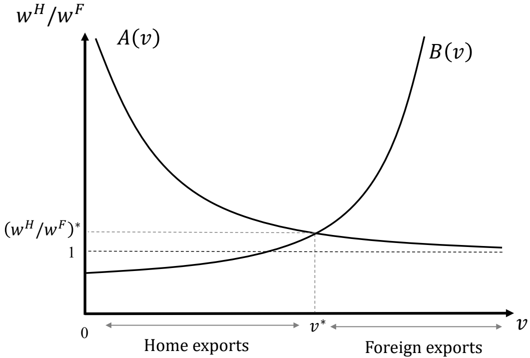
- Labor-market clearing imposes

$$\frac{w^H}{w^F} = \frac{\sum_{n \in \mathcal{N}^H} \alpha_n \beta_n e^{-\sum_{m=n}^{N} \alpha_m \zeta_m}}{\sum_{n \in \mathcal{N}^F} \alpha_n \beta_n e^{-\sum_{m=n}^{N} \alpha_m \zeta_m}} \equiv B\left(v^*\right)$$

Trade Equilibrium with Factor Price Differences



Discrete Number of Stages



Continuum of Stages

- Looks analogous to Dornbusch et al. (1977), but note that the $A(v)$ schedule is endogenous and shaped by differences in interest rates

Trade Equilibrium with Factor Price Differences

- Equilibrium r^H and r^F can be solved invoking capital-market clearing
- Capital intensity at stage n in country j can be expressed as

$$\frac{K_n^j}{L_n^j} = \frac{w^j}{r^j} \frac{1}{\alpha_n} \left(e^{\alpha_n \zeta_n} - 1 \right),$$

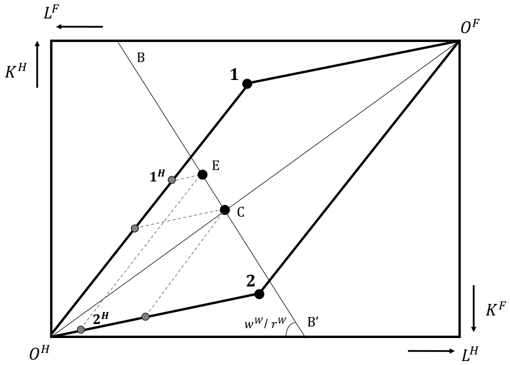
- Imposing capital-market clearing, we then get

$$\frac{r^F}{r^H} = \frac{\sigma\left(r^H, \rho^H\right)}{\sigma\left(r^F, \rho^F\right)} \times \frac{\sum\limits_{n \in \mathcal{N}^F} L_n^F \frac{1}{\alpha_n} \left(e^{\alpha_n \zeta_n} - 1\right)}{\sum\limits_{n \in \mathcal{N}^H} L_n^H \frac{1}{\alpha_n} \left(e^{\alpha_n \zeta_n} - 1\right)}.$$

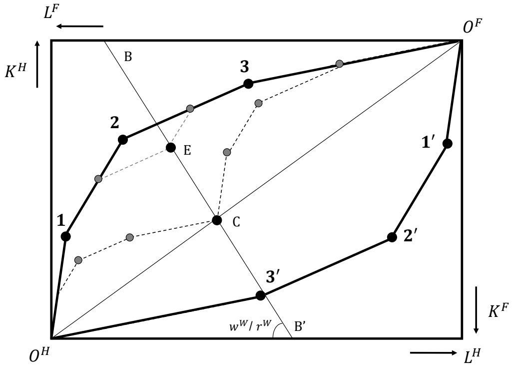
- As long as the right-hand side this equation is higher than one (e.g., small differences in K intensity across stages), the equilibrium will indeed entail a lower interest rate at Home

Trade Equilibrium with Factor Price Equalization

- What if there is FPE? Then labor productivity differences across countries vanish, and we are back to Heckscher-Ohlin model. Only capital intensity matters!



Two-Stage ($N = 2$) Case



Four-Stage ($N = 4$) case

Link to the Heckscher-Ohlin Model

- With FPE, model seemingly collapses to a standard two-factor Heckscher-Ohlin model
- Only capital intensity matters, which for each sector n we can write as

$$\frac{K_n^j}{L_n^j} = \frac{\lambda_n}{1-\lambda_n}\frac{w^j}{r^j},$$

where

$$\lambda_n = \frac{e^{\alpha_n \zeta_n} - 1}{\alpha_n + e^{\alpha_n \zeta_n} - 1},$$

- But outside the FPE set, the model behaves **very** differently. Only time intensity matters!

$$\frac{p_n^H}{p_n^F} = \frac{a_{Ln}^H}{a_{Ln}^F}\frac{w^H}{w^F} = \left(\frac{w^H\left(r^H\right)^{\zeta_n}}{w^F\left(r^F\right)^{\zeta_n}}\right)^{\alpha_n} \neq \left(\left(\frac{w^H}{w^F}\right)^{1-\lambda_n}\left(\frac{r^H}{r^F}\right)^{\lambda_n}\right)^{\frac{\alpha_n}{1-\lambda_n(1-\alpha_n)}}$$

Trade Costs and GVC activity

Costly Trade: Standard Iceberg Trade Costs

- This is not as simple as in the (seemingly) isomorphic Dornbusch et al. (1977) paper!
  - In DFS, goods for which relative costs are close to 1 become nontraded
  - Here, decision also depends on relative prices upstream and downstream
- I obtain similar 'bunching' effects as in sequential models of Harms et al. (2012) and Baldwin and Venables (2013)
- But dynamic programming (as in Antràs and de Gortari, 2020) leads to neater characterization
  - A sufficient but *not necessary* condition for Foreign producers at stage $n+1$ to choose Foreign as a source of inputs at stage n is

$$w^H \left(r^H\right)^{\zeta_n} > w^F \left(r^F\right)^{\zeta_n}$$

  - Thus, they may choose Foreign even when $w^F \left(r^F\right)^{\zeta_n} > w^H \left(r^H\right)^{\zeta_n}$, which indicates a disproportionate desire to bunch contiguous stages in the same location

Costly Trade: Time as a Trade Barrier

- By incorporating an explicit time value of money, framework can easily accommodate a temporal dimension of trade costs
  - Assume that shipping goods across borders involves an additional interval of time d
- Insight #1: Temporal trade costs have no bearing on the length of production processes
- Insight #2: Temporal trade costs generate same effects as standard trade costs
  - Bunching of contiguous stages, less GVC activity
- Insight #3: Reductions in interest rates worldwide tend to increase the extent to which goods cross borders, hence generating a higher amount of 'GVC' trade
- Insight #4: As long as no FPE, $\tau^{HF} < \tau^{FH}$.
  - Asymmetric bilateral trade costs consistent with evidence in Waugh (2010)

Financial Frictions and Trade Credit

Financial Frictions

- Suppose collecting interest involves monitoring costs m^j in country j
- Supply of capital at any point in time is now

$$(K^s)^j = w^j L^j \times \sigma\left(r^j, \rho^j, m^j\right),$$

with $\sigma^j = 1/\left(\rho^j + m^j - r^j\right)$ increasing in r^j and decreasing in ρ^j and m^j

- Under autarky, interest rates are higher in countries with higher monitoring costs
- As long as monitoring international loans is infinitely costly, not much changes from prior analysis (except for effect of m^j on $(K^s)^j$)
- New: comparative advantage shaped by financial ‘development’, not just impatience
- But what if monitoring costs are relatively low between buyers and sellers? Trade credit

Trade Credit

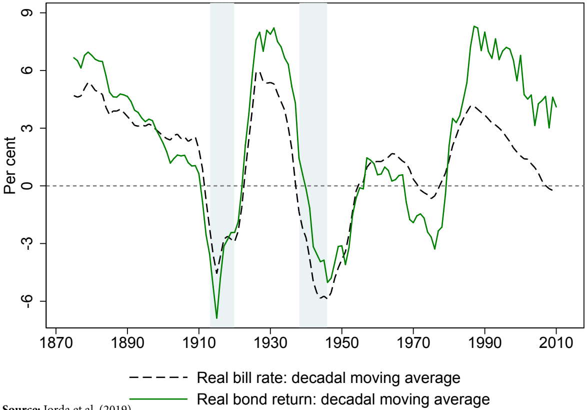
- What if exporters/importers from low interest rate countries lend to importers/exporters in high interest rate countries?
- Insight #1: International trade credit expands the factor price equalization set
  - *Per se*, this is a force toward less trade (Mundell, 1957)
- Insight #2: Trade credit reduces the benefit of bunching contiguous stages and thus results in an increase in the share of world trade that is GVC trade
  - *Per se*, this is a force toward more trade
  - Overall effect of capital flows on trade flows is ambiguous
- Insight #3: Trade Finance (i.e., borrowing and lending related to trade costs, not production costs) generates effects analogous to combination of trade credit and trade cost reductions

Conclusions

- I develop a stylized model of sequential production with N stages in which the time length of each stage is endogenously determined
- Letting the production process *mature* increases labor productivity, but it comes at the cost of higher working capital needs for firms
- 'Austrian' notion of capital has different implications for the pattern of specialization than the Clark-Samuelson notion of capital
- Incorporating an explicit notion of time and modeling interest rates has implications for:
  - The role of temporal trade costs in shaping specialization
  - The effects of trade credit and trade finance
- Many potential extensions come to mind: scale economies, imperfect competition, financial frictions, firm heterogeneity, etc.

Low Interest Rates in Historical Perspective

Figure 3: *Trends in real returns on bonds and bills*



Source: Jorda et al. (2019)