Import Constraints

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Since 2020, a panoply of shocks have buffeted global supply chains: shutdowns in global production hubs, congestion at ports, trucking shortages, disruptions in maritime shipping, pervasive inventory shortages, energy and raw material shocks, and export bans. These shocks have been widely seen as contributing to macroeconomic dislocation and inflation during the post-pandemic economic recovery.

In Comin, Johnson and Jones (2023), we develop a macroeconomic framework that features occasionally binding production capacity constraints in the supply chain, and we argue that these constraints played an important role in explaining the rise and fall of US inflation during 2021-2023.

In this paper, we instead focus attention on import constraints, by which we mean an upper bound on the quantity of imports at a given date. We think of these constraints as arising from shipping or import logistics capacity, and we provide narrative evidence to support this interpretation below. Our analysis makes two points.

First, the impact of import constraints depends on whether prices adjust in response to the binding constraint, and we show this by comparing how inflation responds to a domestic demand shock in two alternate scenarios. The first scenario assumes that foreign firms pay higher trade costs to access the domestic market when the constraint is binding (i.e., shipping and logistics capacity is maxed out). In the second scenario, we assume that there is a market failure, such that market access is not priced. While import price inflation rises in the first scenario when the constraint binds, it is essentially unchanged in the second, which seems counterfactual.

Second, when trade costs adjust in response to the binding constraint, foreign producer price inflation falls on impact. Further, import prices adjust symmetrically for consumption goods and inputs, because the constraint applies to all imports. Lastly, import quantities rise more for inputs than final goods. These predictions all appear counterfactual based on post-pandemic data, which suggests that import constraints (of the type modelled here) may not have played a large role in explaining inflation.

I. Elements of the Framework

To fix ideas, we start with a simple import pricing problem with monopolistic competition and flexible prices, in which importers pay a trade intermediation cost to access the domestic market. We then introduce an aggregate import constraint and discuss how the trade cost is determined.

A. Import Prices

For concreteness, let the United States be the home country. Suppose there is a unit continuum of monopolistically competitive foreign firms. Individual foreign varieties, denoted by $\varpi \in (0,1)$, are aggregated into a composite foreign good Y_t^*, and this composite is sold in the US. The foreign firm has marginal costs (expressed in US Dollars) given by $E_t MC_t^*$, where E_t is the Dollar exchange rate. Further, the foreign firm pays a fee (in Dollars) of F_t to sell each unit

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of output on the domestic market, which it takes as given. It suffices to think of F_t as a per unit (specific) trade cost for now.[1]

With flexible prices, the foreign firm chooses its price in US Dollars, $P_{Ft}(\varpi)$, to maximize its profits, taking its costs and aggregate variables as given, and with knowledge of its demand curve:

$$\text{(1)} \quad \max_{P_{Ft}(\varpi)} \left(P_{Ft}(\varpi) - E_t MC_t^* - F_t\right) Y_t^*(\varpi) \\ \text{s.t.} \quad Y_t^*(\varpi) = \left(\frac{P_{Ft}(\varpi)}{P_{Ft}}\right)^{-\kappa} Y_t^*,$$

where $Y_t^*(\varpi)$ is the firm's output, P_{Ft} and Y_t^* are the price and quantity of the composite import good, and $\kappa > 1$ is the demand elasticity. The optimal price is:

$$\text{(2)} \quad P_{Ft}(\varpi) = \left(\frac{\kappa}{\kappa - 1}\right)\left(E_t MC_t^* + F_t\right).$$

Note that $P_{Ft}(\varpi)$ is the delivered price to the consumer, inclusive of F_t; in trade parlance, this would be a "CIF" (cost, insurance, and freight) price. The net price that the producer receives is:

$$\text{(3)} \quad \tilde{P}_{Ft}(\varpi) = P_{Ft}(\varpi) - F_t \\ = \left(\frac{\kappa}{\kappa - 1}\right)\left(E_t MC_t^* + \frac{1}{\kappa} F_t\right)$$

This corresponds to a "FOB" (free on board) producer price, and it increases with the trade cost because the supplier marks up its total costs $(E_t MC_t^* + F_t)$.

B. Aggregate Import Constraints

We assume that there is a potentially binding constraint on imports, which limits the aggregate quantity of imports. Let $\bar{M}$ be maximal quantity of imports by Home. And let Home's total import demand be given by: $M_{Ft} \equiv \int_0^1 M_{Ft}(\varpi) d\omega$, where $M_{Ft}(\varpi)$ is the quantity of variety ϖ.[2] The import constraint is then $M_{Ft} \leq \bar{M}$.[3]

[1]See Irarrazabal, Moxnes and Opromolla (2015) on monopolistic competition with per unit trade costs.

[2]With flexible prices, $M_{Ft}(\varpi) = Y_t^*(\varpi)$.

[3]While we assume is $\bar{M}$ is constant, the framework could easily accommodate time-varying constraints.

Several points are useful to note here. First, because this is an aggregate constraint, individual foreign firms do not (directly) take it into account when they set their optimal prices. Second, the import constraint operates as a quantity restriction on imports; this is essentially similar to a quota, and we elaborate on this point below. However, the origin of the constraint is not based in trade policy. Rather, our preferred interpretation is that it represents capacity constraints in transport and logistics infrastructure.

There is ample evidence that transport and logistics capacity constrained imports during the pandemic recovery.[4] Set against limited capacity to move imports, there was a surge in demand for transport and logistics services, as macroeconomic demand recovered in 2021. Correspondingly, both maritime shipping and air freight rates escalated sharply. Congestion and backlogs at ports also increased, leading to delays in moving goods across the border.[5]

C. Determination of Trade Costs

To link the discussion of import prices and constraints, we now turn to questions about how the trade cost (F_t) is determined. To be clear, we intentionally provide a stylized setup to fix ideas, rather than a detailed model of the transport and logistics sector (though that is a useful direction for research). The key issue we focus on concerns whether the cost of accessing the domestic market is linked to whether the import constraint binds.

[4]In the first half of 2020, the collapse in demand for maritime shipping led to cancellation of planned voyages. During the ensuing recovery, global tonnage grew slowly. The pandemic also curtailed air freight capacity, as international commercial air traffic stalled. Moreover, idiosyncratic shocks left transport networks in disarray, with crews, vessels, and containers out of sync across the globe. At ports of entry, disease outbreaks and personnel policies to manage disease spread restricted operational capacity. See `https://www.usitc.gov/research_and_analysis/tradeshifts/2020/special_topic.html`.

[5]Bai et al. (2023) and Finck and Tillmann (2023) use shipping disruptions to study the empirical propagation of supply chain shocks. Alessandria et al. (2023) analyze the macroeconomic impacts of shipping delays in a model with inventory holdings.

First, suppose they are linked. As a simple micro-foundation to motivate this case, maritime ports have a fixed capacity to process containers, which constrains the quantity of imports at a given date. Suppose there is a "port authority" that charges a fee to clear each container. When the port has excess capacity, assume this is a flat fee (e.g., the port may have constant marginal costs of processing containers), and normalize its level to zero: $F_t = 0$ if $M_{Ft} < \bar{M}$. Then, when the constraint is binding, the port authority will optimally impose a surcharge: $F_t \geq 0$ if $M_{Ft} = \bar{M}$.[6] This pricing scheme is essentially like administering a quota, where the importer auctions the quota rights.[7] Further, when the constraint binds, F_t will be optimally set based on willingness to pay for imports, to equate the demand for imports with the constrained supply.

As an alternative micro-foundation, consider a setup with Bertrand competition among shipping firms, where each firm has constant marginal costs and fixed firm-specific capacity. Total import capacity is the sum of capacity across these firms. When *aggregate* industry capacity is slack, all firms will set prices equal to marginal cost (again, set this to zero). That is, even constrained firms price at marginal cost, because unconstrained firms provide pricing discipline. When aggregate capacity is binding, however, the Bertrand equilibrium features prices in excess of marginal cost. As a result, the price schedule again has $F_t = 0$ if $M_{Ft} < \bar{M}$ and $F_t \geq 0$ if $M_{Ft} = \bar{M}$, with F_t set by pricing to demand when the constraint binds.

Though this is not a realistic model of the shipping industry, it captures an essential element of the post-2020 experience. As import constraints were triggered, shipping profits exploded, despite adverse cost shocks related to fuels, personnel, et cetera.[8]

At the opposite end of the spectrum, the second case worth considering is one in which trade costs are delinked from whether the import constraint binds. In this case, set $F_t = 0$ at all times, regardless of whether the constraint binds or not. This is like having an import quota with property rights that are not well defined, so quota rents cannot be harvested. More directly, it is likely that port surcharges and freight rates do not fully adjust when the constraint binds; note that there was evident congestion at ports, with ships queuing for berths and containers trapped in warehouse limbo. When markets for imports do not clear via adjustment in prices, we must specify an allocation rule for the (constrained) quantity of imports, and we discuss this further below.

II. Small Open Economy Model

The three elements laid out above – monopolistic competition with per unit trade costs, an aggregate import constraint, and the market for trade intermediation subject to the constraint – provide a bare bones structure for studying the impact of potentially binding import constraints on inflation. To do so, we now turn to a small open economy model with sticky prices. Details of the model are relegated to the Online Appendix, so we can focus here on how import prices are determined.

A. *Sticky Import Prices*

As above, there is a unit continuum of symmetric, monopolistically-competitive foreign firms, and these firms set prices in US dollars subject to quadratic costs of price adjustment. How import prices behave then depends on the model regime, whether the import constraint is binding or

[6] Maritime companies imposed "congestion surcharges" at the busiest ports during the COVID period.

[7] This analogy was inspired by Jørgensen and Schröder (2007).

[8] "[S]hipping lines enjoyed record profits as ships queued up at ports to unload and customers raced to get goods on to a diminishing number of available vessels. . . In the three years from 2020 to 2022, the industry generated as much profit as it had during the previous six decades combined." Later in the same article: "they [Mediterranean Shipping Company] maxed out and charged whatever they could for every container." Source: Telling, Oliver and Richard Milne. 2023. "The shipping rivals plotting divergent courses on global trade." *The Financial Times*, June 23. `https://on.ft.com/43XMjqi`.

slack, and whether it is priced or not when it is binding.

We log linearize the firm's first-order condition for optimal prices to obtain an import price Phillips Curve:

$$\pi_{Ft} = \left(\frac{\kappa - 1}{\phi}\right)\left(\hat{e}_t + \widehat{mc}^*_t - \hat{p}_{Ft}\right) + \frac{\kappa}{\phi}\frac{P_0}{P_{F0}}\hat{\bar{f}}_t + \beta \mathbf{E}_t \pi_{t+1}, \tag{4}$$

where the hat-notation denotes log deviations from steady state, π_{Ft} is inflation for consumer import prices in Dollars in period t, e_t is is the log exchange rate, mc^*_t is log foreign marginal costs in foreign currency, p_{Ft} is the import price in Dollars, β is the consumer's time discount rate, ϕ controls the degree of price rigidity, and P_{F0}/P_0 is the the steady-state relative price of imports. Finally, assuming that trade costs are zero in the steady state ($F_0 = 0$), we define an auxiliary variable $\bar{F}_t = 1 + F_t/P_t$, and we take the approximation with respect to $\bar{F}_t$, so $\hat{\bar{f}}_t \equiv \ln\left(\bar{F}_t\right)$.

In Equation 4, import price inflation responds to changes in both foreign costs and the trade cost. Recall that foreign producer prices are given by $\tilde{P}_{Ft} = P_{Ft} - F_t$, so then foreign producer price inflation is $\tilde{\pi}_{Ft} = \pi_{Ft} - (P_0/P_{F0})(\hat{\bar{f}}_t - \hat{\bar{f}}_{t-1})$.

Now consider alternative approaches to the binding import constraint. When trade costs adjust in response to the binding constraint, then $\hat{\bar{f}}_t > 0$. In this case, the binding constraint implies that:

$$\left(\frac{C_{F0}}{M_0}\right)\hat{c}_{Ft} + \left(\frac{N_{F0}}{M_0}\right)\hat{n}_{Ft} = \ln\left(\frac{\bar{M}}{M_0}\right), \tag{5}$$

where $\bar{M}/M_0$ is the ratio of the constrained import quantity to steady-state imports, C_{Ft} is imports of consumer goods, and N_{Ft} is imports of intermediate inputs. This constraint is added to the equilibrium system, and it effectively pins down the price of imports inclusive of trade costs. The value of the trade cost needed to clear the import market may then then calculated using Equation 4.

When the import constraint binds, but trade costs do not adjust, then $\hat{\bar{f}}_t = 0$ in Equation 4. We then also impose the constraint in Equation 5 together with an assumption about how constrained imports are allocated to consumers versus firms as inputs. We assume that constrained imports are allocated to end uses based on relative demand for consumption versus inputs.

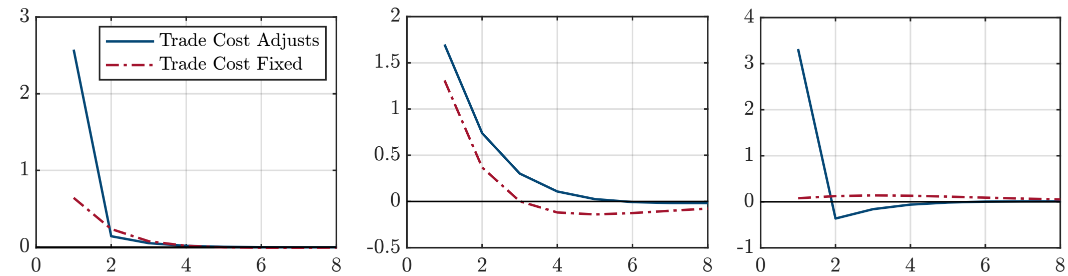
B. *Quantitative Analysis*

We now consider the effects of a Home demand shock: a temporary increase in the discount rate of the Home consumer. Whether the import constraint binds is endogenous, and the model is non-linear, so we solve the model using a piecewise linear approximation, as in Guerrieri and Iacoviello (2015). Model equilibrium conditions and parameters are discussed in the Online Appendix.

In Figure 1, we plot impulse responses for consumer price inflation, inflation for domestically-produced goods, and import price inflation following a temporary (but persistent) increase in Home aggregate demand. Excess import capacity and the demand shock are jointly set so the import constraint is triggered on impact, but binds only for one period. We simulate two versions of the model, one in which trade costs adjust to the binding constraint and one in which they do not (i.e., $\hat{\bar{f}}_t = 0$ by assumption).

In Figure 1a, inflation rises due to the positive demand shock, and more so when trade costs rise due to the binding constraint. Referring to Figures 1b and 1c, import price inflation explains this difference. When the constraint leads trade costs to rise, import price inflation increases a lot. In contrast, import price inflation is tepid when the trade cost is fixed. Thus, the existence of an import constraint alone does not imply that a domestic demand shock raises import price inflation. Rather, the binding constraint raises inflation only when it leads trade intermediation costs to rise.

On this basis, it is tempting to conclude that import constraints with endogenous trade costs might underlie the combined im-



(a) Consumer Price Inflation: π_t (b) Domestic Price Inflation: π_{Ht} (c) Import Price Inflation: π_{Ft}

Figure 1. : Inflation with Binding Import Constraints

Note: Sub-figures present responses for a demand (discount rate) shock that leads the import constraint to bind for one period. The y-axis is in percentage points, where inflation is the annualized quarterly value. The x-axis records periods (quarters) after the shock.

port and consumer price inflation experienced during the post-pandemic economic recovery. Looking under the hood of the model, we raise several counter-arguments.

First, recall that π_{Ft} is import price inflation from the buyer's perspective. In Figure 2a, we plot inflation in the net price received by the producer, stripping out the trade cost: $\tilde{\pi}_{Ft}$. While π_{Ft} rises on impact, $\tilde{\pi}_{Ft}$ falls, because pass-through from trade costs to import prices is incomplete. $\tilde{\pi}_{Ft}$ then rebounds sharply in the second period, due to the declining wedge between buyer and seller prices as the constraint is relaxed. Buyer and seller price inflation then coincides from period 3 forward.

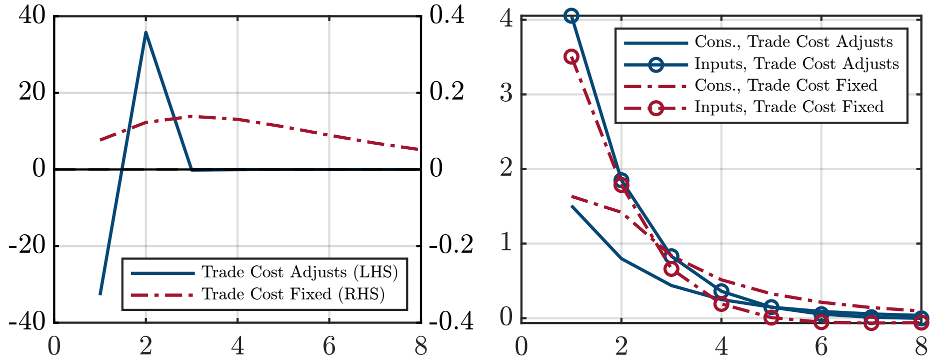
This observation – that foreign producer price inflation is negative when the constraint binds – seems counterfactual. Import price indexes compiled by the Bureau of Labor Statistics (BLS) are primarily based on free-on-board foreign producer prices (excluding trade costs).[9] When import constraints bound most tightly in 2021, BLS-measured import price inflation was high, not low, in the United States.

As a second point regarding prices, we also note that increases in trade costs apply to both consumer goods and inputs. Thus, a binding import constraint leads to high import price inflation for both types of goods. In reality, however, inflation for imported inputs (e.g., industrial materials and supplies) was substantially higher than that for consumer goods during 2021-2022.

Turning to quantities, we plot the volume of imported consumer goods and inputs separately in Figure 2b. While the aggregate quantity of imports is restricted, the model allows for differential changes in the quantity of imports by end use. In particular, the quantity of imported inputs rises relative to the quantity of imported consumer goods. One reason is that domestic production, and hence demand for imported inputs, rises in response to the domestic demand shock. Further, our parameterization of the model assumes that the elasticity of substitution between home and foreign composite goods is higher for consumption than for input use, so there is more scope for substitution on the consumer side.

This prediction is also seemingly counterfactual. In the United States, imports of consumer goods rose dramatically during the post-pandemic recovery, while imported input quantities did not rise relative to pre-2000 levels. Together with the comments on prices above, our conclusion is that an aggregate import constraint does not provide a plausible amplification mechanism for domestic demand shocks on inflation.

[9]While the BLS does not report the exact breakdown of sampled prices by FOB/CIF concept, it states: "[t]he majority of prices used in calculating import price indexes are quoted FOB (Free On Board) Foreign Port." Source: `https://www.bls.gov/mxp/publications/factsheets/import-export-price-indexes-technical-addendum.htm`.



(a) Foreign Producer Price Inflation: $\tilde{\pi}_{Ft}$

(b) Import Quantity for Consumption Goods and Inputs

Figure 2. : Foreign Producer Price Inflation and Import Quantities

Note: Sub-figures present responses for a demand (discount rate) shock that leads the import constraint to bind for one period. For inflation, the y-axis is in percentage points, where inflation is the annualized quarterly value. For quantities, the y-axis is the log deviation from steady state multiplied by 100 for scaling. The x-axis records periods (quarters) after the shock.

III. Conclusion

We have provided a stylized model with potentially-binding constraints on imported goods. We show that import price inflation increases following a domestic demand shock when endogenous trade intermediation costs adjust in response to the binding constraint. Even in this case, we argue that the aggregate import constraint has seemingly counterfactual implications for foreign producer price inflation and relative import quantities of consumer goods versus inputs. Thus, we suggest that other mechanisms are needed to explain changes in import prices and quantities, as well as the downstream implications thereof, over the post-pandemic period.

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