Online Appendices for "Why Special Economic Zones? Using Trade Policy to Discriminate Across Importers"

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Appendix 1: Proofs and related derivations

Derivation of optimal tariffs in the uniform tariff case

The Lagrangian (with a full set of multipliers) for the government problem under uniform tariffs is:

$$\mathcal{L}(\vec{\tau},\vec{\mu},\vec{\nu}) \quad = \quad \max_{\{\tau_i\}_{i\in G\cup H}} \left\{ \Omega + \sum_{i\in G\cup H} \left(\mu_i\tau_i + \nu_i\tau_i M_i\right) \right\}$$

(where the tariff-only constraints are $\tau_i \geq 0$ and $M_i\tau_i \geq 0$). This yields first order conditions:

$$[\text{wrt } \tau_g]\ 0 \quad = \quad \lambda_g y_g + M_g + \tau_g\frac{\partial M_g}{\partial \tau_g} + \sum_{h=1}^{H}\tau_h\frac{\partial M_h}{\partial \tau_g} - x_g + \mu_g + \nu_g\left(M_g + \tau_g\frac{\partial M_g}{\partial \tau_g}\right) + \sum_{h=1}^{H}\nu_h\tau_h\frac{\partial M_h}{\partial \tau_g}$$

$$[\text{wrt } \tau_h]\ 0 \quad = \quad \lambda_h y_h + \sum_{g=1}^{G}\tau_g\frac{\partial M_g}{\partial \tau_h} + M_h + \tau_h\frac{\partial M_h}{\partial \tau_h} - \sum_{g=1}^{G}\lambda_g x_{gh} + \mu_h + \nu_h M_h + \nu_h\tau_h\frac{\partial M_h}{\partial \tau_h} + \sum_{g=1}^{G}\nu_g\tau_g\frac{\partial M_g}{\partial \tau_h}$$

Proof of Proposition 1:

To show that $\tau_{gh} \in \{0,\ p_h - p_h^w\}$, I solve the second stage of the two-step government maximization problem shown in the main text. Note that I assume all $\tau_{gh} \leq p_h - p_h^w$. Technically, the government could set some tariffs higher while still delivering the domestic producer price p_h, but for these industries setting $\tau_{gh} = p_h - p_h^w$ will yield equivalent results in every way (since industries with greater tariffs always have the option of buying domestically at price p_h); this is equivalent to assuming away greater-than-prohibitive user-specific tariffs. The formal government problem (where $x_{gh}^d(p_h,\,\tau_{gh},\tau_g)$ denotes domestic purchases of h by industry g given a final good tariff and user-specific tariff) is:

$$\max_{\{\vec{\tau}_g\},\left\{\vec{\tau}_{gh}\leq p_h - p_h^w\right\}} \Omega$$

$$\begin{aligned} \text{s.t.} \qquad & y_h(p_h) \leq \sum_{g=1}^{G} x_{gh}^d(p_h,\,\tau_{gh},\tau_g) \\ & \tau_g \geq 0 \\ & M_g\tau_g \geq 0 \\ & \tau_{gh} \geq 0 \\ & M_h\left(p_h\right)\tau_{gh} \geq 0 \end{aligned}$$

yielding Lagrangian

$$\begin{aligned}\mathcal{L}\left(\vec{\tau},\,\vec{\nu},\vec{\omega},\vec{\sigma}\right) &= \Omega+\sum_{h=1}^{H}\nu_h\left(\sum_{g=1}^{G}x_{gh}^{d}(p_h,\,\tau_{gh},\tau_g)-y_h(p_h)\right)\\ &\quad+\sum_{g=1}^{G}\left(\omega_g\tau_g+\sigma_g M_g\tau_g\right)+\sum_{g=1}^{G}\sum_{h=1}^{H}\left(\omega_{gh}\tau_{gh}+\sigma_{gh}M_h\left(p_h\right)\tau_{gh}\right)\end{aligned}$$

and hence first order condition with respect to τ_{gh}

$$\begin{aligned}0 &= \tau_g\frac{\partial M_g}{\partial\tau_{gh}}+\tau_{gh}\frac{\partial x_{gh}}{\partial\tau_{gh}}-\left(\lambda_g-1\right)x_{gh}+\nu_h\frac{\partial x_{gh}^{d}(p_h,\,\tau_{gh},\tau_g)}{\partial\tau_{gh}}\\ &\quad+\sigma_g\frac{\partial M_g}{\partial\tau_{gh}}\tau_g+\omega_{gh}+\sigma_{gh}M_h\left(p_h\right)\end{aligned}$$

Note that by assumption, $\tau_{gh}\in(0,p_h-p_h^w)$, so that cost minimization by users implies $x_{gh}^{d}\left(\tau_g,\tau_{gh}\right)=0$ and $\frac{\partial x_{gh}^{d}}{\partial\tau_{gh}}=0$.

Since $\frac{\partial M_g}{\partial\tau_{gh}}=-\frac{\partial y_g}{\partial\tau_{gh}}>0$, if I assume away prohibitive final goods tariffs then the solution to the FOC for τ_{gh} will satisfy

$$0 = -\tau_g\frac{\partial y_g}{\partial\tau_{gh}}+\tau_{gh}\frac{\partial x_{gh}}{\partial\tau_{gh}}-\left(\lambda_g-1\right)x_{gh}$$

Given the assumed production function, profit maximization implies $\frac{\partial y_g}{\partial\tau_{gh}}=\frac{p_h^w+\tau_{gh}}{p_g^w+\tau_g}\frac{\partial x_{gh}}{\partial\tau_{gh}}$. Thus

$$\left(\lambda_g-1\right)\frac{x_{gh}}{\frac{\partial x_{gh}}{\partial\tau_{gh}}} = p_h^w\frac{\frac{\tau_{gh}}{p_h^w}-\frac{\tau_g}{p_g^w}}{1+\frac{\tau_g}{p_g^w}}$$

Since $\left(\lambda_g-1\right)\frac{x_{gh}}{\frac{\partial x_{gh}}{\partial\tau_{gh}}}\le 0$, it must be that $\left(\frac{\frac{\tau_{gh}}{p_h^w}-\frac{\tau_g}{p_g^w}}{1+\frac{\tau_g}{p_g^w}}\right)p_h^w\le 0$ so that the FOC may be satisfied for $\tau_{gh}\in[0,\,\frac{\tau_g}{p_g^w}p_h^w]$. I rule out $\tau_{gh}<0$ based on the restriction to tariffs (so that there may be a corner solution at 0), and there is a point of non-differentiability in $\frac{\partial x_{gh}^{d}(p_h,\tau_{gh},\tau_g)}{\partial\tau_{gh}}$ at $\tau_{gh}=p_h-p_h^w$ which may also be a critical point. Thus $\tau_{gh}\in\left\{[0,\,\frac{\tau_g}{p_g^w}p_h^w],\ p_h-p_h^w\right\}$.

Full Lagrangian for the government problem under cross-importer tariff discrimination:

In this section, I provide the full Lagrangian (with multipliers) and derivation for the FOCs in the full characterization of equilibrium:

$$\begin{aligned}\mathcal{L}(\vec{\tau},\vec{z},\vec{\mu},\vec{\nu},\vec{\omega},\vec{\sigma}) &= \max_{\{\tau_g,p_h,\tau_{gh},z_{gh}\}_{g\in G,\ h\in H}}\{\Omega+\sum_{h=1}^{H}\mu_h\left(p_h-p_h^w\right)\hat{M}_h+\sum_{g=1}^{G}\left[\nu_g\tau_g+\omega_g M_g\tau_g\right]\\ &\quad+\sum_{g=1}^{G}\sum_{h=1}^{H}z_{gh}\left[\nu_{gh}\tau_{gh}+\omega_{gh}\left(p_h-p_h^w-\tau_{gh}\right)+\sigma_{gh}^{U}\left(1-z_{gh}\right)+\sigma_{gh}^{L}z_{gh}\right]\end{aligned}$$

yielding simplified FOCs

$$
\begin{aligned}
[\text{wrt } \tau_g]\ 0 &= (\lambda_g-1)\, y_g + \tau_g \frac{\partial M_g}{\partial \tau_g} + \sum_{h=1}^{H} z_{gh}\tau_{gh}\frac{\partial x_{gh}}{\partial \tau_g} + \sum_{h=1}^{H}\left(p_h - p_h^w + \mu_h\left(p_h - p_h^w\right)\right)\frac{\partial \hat{M}_h}{\partial \tau_g} \\
&\quad + \nu_g + \omega_g M_g + \omega_g \frac{\partial M_g}{\partial \tau_g}\tau_g \\
[\text{wrt } p_h]\ 0 &= \sum_{g=1}^{G}(1-z_{gh})\left[-(\lambda_g-1)\, x_{gh}(p_g,p_h) + \tau_g \frac{p_h}{p_g}\frac{\partial x_{gh}(p_g,p_h)}{\partial p_h}\right] + (\lambda_h-1)\, y_h + (1+\mu_h)(p_h-p_h^w)\frac{\partial \hat{M}_h}{\partial p_h} \\
&\quad + \sum_{h=1}^{H}\left[\nu_h + \mu_h(p_h-p_h^w)\frac{\partial \hat{M}_h}{\partial p_h} + \mu_h \hat{M}_h\right] + \sum_{g=1}^{G}(1-z_{gh})\omega_g \frac{\partial M_g}{\partial p_h}\tau_g \\
[\text{wrt } \tau_{gh}]\ 0 &= -(\lambda_g-1)\, x_{gh}\left(p_g, p_h^w+\tau_{gh}\right) + \tau_g \frac{\partial M_g}{\partial \tau_{gh}} + \tau_{gh}\frac{\partial x_{gh}\left(p_g,p_h^w+\tau_{gh}\right)}{\partial \tau_{gh}} \\
&\quad + \omega_g \frac{\partial M_g}{\partial \tau_{gh}}\tau_g + \nu_{gh} - \omega_{gh}\ (\text{if } z_{gh}\neq 0) \\
[\text{wrt } z_{gh}]\ 0 &= (\lambda_g-1)\frac{\partial \pi_g}{\partial z_{gh}} + \frac{\partial W}{\partial z_{gh}} + \omega_g \frac{\partial M_g}{\partial z_{gh}}\tau_g - \mu_h(p_h-p_h^w)\, x_{gh}(p_g,p_h) + \omega_g \frac{\partial M_g}{\partial z_{gh}}\tau_g - \sigma_{gh}^U + \sigma_{gh}^L \\
[\text{wrt } \mu_h]\ 0 &= (p_h - p_h^w)\,\hat{M}_h
\end{aligned}
$$

Simplification of FOC with respect to z_{gh}:

Here, I derive the expression for $\frac{1}{p_h^w x_{gh}(p_g,p_h)}\frac{\partial \mathcal{L}}{\partial z_{gh}}$ used in the main text.

I start from the FOC in the formal Lagrangian, and drop the multipliers on the constraints $z_{gh}\in[0,1]$ for concision (these terms aren't assumed away, but they don't add any intuition as the industry will be assigned to the lower tier if $\frac{\partial \mathcal{L}}{\partial z_{gh}} > 0$ and not if $\frac{\partial \mathcal{L}}{\partial z_{gh}} < 0$). Note that the change in welfare due to a SEZ ($\frac{\partial W}{\partial z_{gh}}$) will simply be the change in (net) home output, valued at world prices. I take a second-order approximation to the final industry profits around the price vector (p_g, p_h). Note that $p_{gh} = z_{gh}(\tau_{gh}+p_h^w) + (1-z_{gh})\,p_h$. I denote output of g stemming from the use of intermediate h by y_{gh}. Then, using Hotelling's Lemma and profit maximization:

$$
\begin{aligned}
\pi_{gh}(p_g', p_{gh}') &= \overline{\pi}_{gh}(p_g,p_h) + \overline{y}_{gh}(p_g,p_h)\left(p_g'-p_g\right) - \overline{x}_{gh}(p_g,p_h)\left(p_{gh}'-p_h\right) \\
&\quad + \frac{1}{2}\left(\frac{\partial \overline{y}_{gh}(p_g,p_h)}{\partial p_g}\right)\left(p_g'-p_g\right)^2 - \frac{1}{2}\left(\frac{\partial \overline{x}_{gh}(p_g,p_h)}{\partial p_{gh}}\right)\left(p_{gh}'-p_h\right)^2 \\
&\quad + \frac{p_h}{p_g}\frac{\partial \overline{x}_{gh}(p_g,p_h)}{\partial p_{gh}}\left(p_{gh}'-p_h\right)\left(p_g'-p_g\right)
\end{aligned}
$$

I simplify notation by defining $\tau_h \equiv p_h - p_h^w$ and $t_i \equiv \frac{\tau_i}{p_i w}, i\in\{g,h,gh\}$ and make the following approximations:

$$
\begin{aligned}
\frac{1}{p_h^w x_{gh}(p_g,p_h)}\frac{\partial \pi_g}{\partial z_{gh}} &= t_h - t_{gh} + \frac{1}{2}\frac{\left(t_{gh}-t_h\right)^2}{1+t_h} e_{p_{gh}}^{x_{gh}} \\
p_g^w \frac{1}{x_{gh}(p_g,p_h)}\frac{\partial y_g}{\partial z_{gh}} &= \frac{t_h - t_{gh}}{1+t_g} p_h^w e_{p_{gh}}^{x_{gh}} \\
\frac{x_{gh}\left(\tau_{gh}+p_h^w, p_h\right) - x_{gh}(p_g,p_h)}{x_{gh}(p_g,p_h)} &= \frac{t_h - t_{gh}}{1+t_h} e_{p_{gh}}^{x_{gh}} \\
\frac{1}{x_{gh}(p_g,p_h)}\frac{\partial W}{\partial z_{gh}} &= \frac{(t_h-t_{gh})(t_h-t_g)}{(1+t_g)(1+t_h)} p_h^w e_{p_{gh}}^{x_{gh}}
\end{aligned}
$$

so that returning to the FOC with respect to z_{gh}:

$$\begin{aligned}\frac{1}{p_h^w x_{gh}(p_g,p_h)}\frac{\partial\mathcal{L}}{\partial z_{gh}} &= (\lambda_g-1)\left[t_h-t_{gh}+\frac{1}{2}\frac{(t_{gh}-t_h)^2}{1+t_h}e^{x_{gh}}_{p_{gh}}\right]+\frac{(t_h-t_{gh})(t_h-t_g)}{(1+t_g)(1+t_h)}e^{x_{gh}}_{p_{gh}}\\ &\quad -\mu_h t_h-\omega_g\frac{t_g}{1+t_g}(t_h-t_{gh})e^{x_{gh}}_{p_{gh}}\end{aligned}$$

Proof of Proposition 2:

Throughout the proof, I make use of the first order conditions characterizing optimal policy under cross-importer tariff discrimination which are presented in the text and derived earlier in this appendix.

Suppose not; then it must be that the government could not gain from reducing the $g-h$ tariff on any good for which $z_{gh}=0$, i.e. that $\tau_{gh}\geq p_h-p_h^w$ for all goods at the upper-tier. This implies $\mu_h=0$ (note also that $p_h>p_h^w$ so that $\nu_h=0$). Taking this into account, the FOC with respect to p_h is

$$\begin{aligned}-(p_h-p_h^w)\frac{\partial\hat{M}_h}{\partial p_h} &= \sum_{g=1}^{G}(1-z_{gh})\left[-(\lambda_g-1)x_{gh}(p_g,p_h)+\tau_g\frac{p_h}{p_g}\frac{\partial x_{gh}(p_g,p_h)}{\partial p_h}\right]\\ &\quad +(\lambda_h-1)y_h+\sum_{g=1}^{G}(1-z_{gh})\omega_g\frac{\partial M_g}{\partial p_h}\tau_g\end{aligned}$$

Furthermore, for any final good, the FOC with respect to τ_{gh} if it were assigned to the lower tier tariff is

$$\begin{aligned}0=&-(\lambda_g-1)x_{gh}(p_g,p_h^w+\tau_{gh})+\tau_g\frac{\partial M_g}{\partial\tau_{gh}}+\tau_{gh}\frac{\partial x_{gh}(p_g,p_h^w+\tau_{gh})}{\partial\tau_{gh}}\\ &+\omega_g\frac{\partial M_g}{\partial\tau_{gh}}\tau_g+\nu_{gh}-\omega_{gh}\end{aligned}$$

For all goods remaining at the upper tier, it must be that $\omega_{gh}\geq 0$ and $\tau_{gh}=p_h-p_h^w$ (implying $\nu_{gh}=0$), so that

$$\begin{aligned}0\leq\omega_{gh} &= -(\lambda_g-1)x_{gh}(p_g,p_h)+\tau_g\frac{\partial M_g}{\partial p_h}\\ &\quad +(p_h-p_h^w)\frac{\partial x_{gh}(p_g,p_h)}{\partial p_h}+\omega_g\frac{\partial M_g}{\partial\tau_{gh}}\tau_g\\ -(p_h-p_h^w)\frac{\partial x_{gh}(p_g,p_h)}{\partial p_h} &\leq -(\lambda_g-1)x_{gh}(p_g,p_h)+\tau_g\frac{\partial M_g}{\partial p_h}+\omega_g\frac{\partial M_g}{\partial\tau_{gh}}\tau_g\end{aligned}$$

and hence by summing across all using industries at the upper tier,

$$\begin{aligned}-(p_h-p_h^w)\frac{\partial\hat{M}_h}{\partial p_h}\leq&\sum_{g=1}^{G}(1-z_{gh})\left[-(\lambda_g-1)x_{gh}(p_g,p_h)+\tau_g\frac{p_h}{p_g}\frac{\partial x_{gh}(p_g,p_h)}{\partial p_h}\right]\\ &+\sum_{g=1}^{G}(1-z_{gh})\omega_g\frac{\partial M_g}{\partial p_h}\tau_g\end{aligned}$$

But also, from the FOC with respect to p_h and the assumptions that $K_h > 0$ and $\lambda_h > 1$ (which implies $(\lambda_h - 1)\, y_h > 0$),

$$-\left(p_h - p_h^w\right)\frac{\partial \hat{M}_h}{\partial p_h} > \sum_{g=1}^{G}(1 - z_{gh})\left[-\left(\lambda_g - 1\right) x_{gh}\left(p_g, p_h\right) + \tau_g \frac{p_h}{p_g}\frac{\partial x_{gh}\left(p_g, p_h\right)}{\partial p_h}\right] + \sum_{g=1}^{G}(1 - z_{gh})\omega_g \frac{\partial M_g}{\partial p_h}\tau_g$$

implying $-\left(p_h - p_h^w\right)\frac{\partial \hat{M}_h}{\partial p_h} > -\left(p_h - p_h^w\right)\frac{\partial \hat{M}_h}{\partial p_h}$ which is impossible.

Proof of Corollary to Proposition 2:

I use a $'$ to denote values in the second period. Since Proposition 2 is satisfied in the second period, $\hat{M}_h' = 0$, and trivially $\hat{M}_h \geq 0$. By assumption, $M_h' > M_h$. Therefore, $M_h' - \hat{M}_h' = M_h' > M_h \geq M_h - \hat{M}_h$ so that $M_h' - \hat{M}_h' > M_h - \hat{M}_h$ and imports under lower tier tariffs must increase.

Proof of Proposition 3:

Using the FOC for tier assignment (with respect to z_{gh}) derived earlier in this appendix, any industry such that

$$\mu_h t_h \leq \left(\lambda_g - 1\right)\left[t_h - t_{gh} + \frac{1}{2}\frac{\left(t_{gh} - t_h\right)^2}{1 + t_h} e^{x_{gh}}_{p_{gh}}\right] + \frac{\left(t_h - t_{gh}\right)\left(t_h - t_g\right)}{\left(1 + t_g\right)\left(1 + t_h\right)} e^{x_{gh}}_{p_{gh}} - \omega_g \frac{t_g}{1 + t_g}\left(t_h - t_{gh}\right) e^{x_{gh}}_{p_{gh}}$$

will be assigned to the lower tier.[1] Holding other parameters fixed, the right hand side is strictly increasing in λ_g and decreasing in t_g. Furthermore, this inequality is less likely to be satisfied when μ_h is large. This is the Lagrange multiplier on the constraint that $\hat{M}_h\left(p_h - p_h^w\right) > 0$, and so captures the gain of moving the marginal final goods industry to the lower tier. When other using final goods industries have larger political weights and are protected in equilibrium by lower final goods tariffs, this shadow value will be larger.

Tariff-only constraints and Proposition 3:

The term $-\omega_g \frac{t_g}{1+t_g}\left(t_h - t_{gh}\right) e^{x_{gh}}_{p_{gh}}$ is in the FOC with respect to z_{gh} presented in this appendix, but is omitted from the main text. The ω_g is the Lagrange multiplier on the constraint eliminating export subsidies. An export subsidy is necessary to raise the wedge between domestic prices and world prices beyond the prohibitive tariff; thus this multiplier will be 0 if equilibrium tariffs are less than prohibitive. If tariffs are prohibitive, then the multiplier is positive and an increase in output will lower the prohibitive tariff and will impose a shadow cost. Thus, this term captures the shadow cost of increased final goods industry output due to lower intermediate prices. This term is independent of political weights and larger (less negative) when t_g is smaller. The intuition is that with a smaller t_g, the same decrease in t_{gh} changes the FOC for profit-maximizing intermediate use less, and thus to a second order leads to a smaller increase in output.

[1] I assume the optimal lower tier tariff for this $g - h$ pair is less than the upper tier tariff.

Proof of Corollary to Proposition 3:

Combining an inverted tariff rule ($t_{gh} = t_g$ for all g and h) with the assumption that final goods tariffs are not prohibitive (which implies $\omega_g = 0$, since this is the multiplier on the constraint eliminating export subsidies) and the FOC with respect to z_{gh} (derived earlier in this appendix) implies that any industry such that

$$\mu_h t_h \leq (\lambda_g - 1)\left[t_h - t_g + \frac{1}{2}\frac{(t_g - t_h)^2}{1 + t_h}\right] e_{p_{gh}}^{x_{gh}} + \frac{(t_h - t_g)(t_h - t_g)}{(1 + t_h)(1 + t_g)} e_{p_{gh}}^{x_{gh}}$$

will be assigned to the lower tier. [2] Both right-hand side terms are strictly positive and increasing in $e_{p_{gh}}^{x_{gh}}$, so for a larger value of $e_{p_{gh}}^{x_{gh}}$ the relationship is more likely to be satisfied.

Appendix 2: Theoretical assumptions and extensions

In this appendix, I explore some of the important assumptions underlying the model, and discuss the robustness of the results to extensions or relaxation of these assumptions.

Appendix 2.1: Restriction of instruments to tariffs

In the main text, I limit trade policy to tariffs. Although there is significant precedent for this assumption, it is not always made. In this section, I summarize the literature on this point and argue that it is consistent with my approach.

Restricting government policy to import taxes is both necessary to yield results qualitatively consistent with real-world trade policy and realistic given a variety of legal restrictions on governments' ability to use non-tariff trade instruments. It is well-known in the literature that if a model like that in Grossman and Helpman (1994) does not restrict the set of government to using trade instruments (ruling out production subsidies or lump-sum transfers), the government would not use trade policies at all (see Dixit (1996)). In this paper, if the use of export subsidies is not restricted, the model predicts that export subsidies will be the only instrument used to protect intermediate goods. This is not consistent with the reality of trade policy.[3]

Restricting the set of available instruments is also consistent with the fundamental approach of virtually all political economy models of trade policy, including many papers that restrict government policy to tariffs ((e.g., Grossman and Helpman (1995b), Ossa (2014), Bagwell and Staiger (2011), and Maggi (1999)). Arguments for why governments may use trade policy instead of subsidies are summarized and examined empirically in Ederington and Minier (2006). They find support for "obfuscation" arguments in favor of tariffs (tariffs are harder for citizens to identify as redistributionary than direct monetary transfers from the government), time-inconsistency arguments in favor of tariffs (tariffs may induce less dynamic distortion than subsidies), and revenue arguments in favor of tariffs (governments may have trouble raising revenue). All of these arguments apply equally well against export subsidies, which are as easily observed as production subsidies, have greater dynamic-distortions than tariffs, and decrease rather than raise revenue.

[2] Implicitly, I assume $t_g < t_h$; otherwise assignment to the lower tier would have no effect.

[3] If the government is permitted unlimited use of export subsidies, it will move all final goods production to SEZs and then redistribute surplus to intermediate producers using export subsidies. The reason is that this eliminates the consumption distortion that usually arises from trade protection, and so is a more efficient way to transfer surplus to intermediate producers than a tariff. In fact, this combination of the ability to discriminate and the ability to use export subsidies is equivalent to the ability to use a production subsidy on intermediate goods.

Empirically, import restrictions (non-tariff barriers, quotas, and tariffs) are the most common form of trade policy (see, e.g., Ossa (2014)).[4] This reflects restrictions on the use of other trade instruments: Grossman and Helpman (1995b) point out that GATT/WTO rules prohibit export subsidies and that export taxes are banned by the U.S. Constitution. This is not to say that export subsidies are never used[5], and there have been disputes in the WTO in which countries allege that their trading partners are using illegal export subsidies. However, for a rich country like the U.S., the use of export subsidies is significantly constrained (if not eliminated) by GATT/WTO rules. Even if rich countries are able to evade the rules on occasion, it is unlikely that the WTO rules are so toothless that an outcome with such heavy use of export subsidies is possible; nor do we see such an outcome in reality. Ruling out the use of export subsidies entirely is a simple way to eliminate this empirically inconsistent outcome, and the model I construct shows how SEZs will be used when export subsidies are significantly constrained even if not entirely eliminated.

Appendix 2.2: Other rationales for tariffs:

Although politics is a widely accepted motivation for tariffs, second-best arguments for tariffs are also made. In this section, I show how the results extend to a setting where tariffs are no driven by politics, but instead are being used as a second-best instrument to correct production externalities (e.g. external scale economies).

Although I focus on political motives for tariffs, this is not necessary for my results. In fact, if the government values welfare (but places no additional weight on industry profits) and is using tariffs as a second-best instrument to correct positive production externalities $E_i(y_i)$ associated with the production a good $i \in \{g, h\}$,and I assume $E_i'(y_i) \geq 0$ (e.g. scale economies). In this setup, the objective function of the government will be

$$\Omega^e = W + \sum_g E_g(y_g) + \sum_h E_h(y_h)$$

This framework will yield a two-tiered result, even without political motives, as the government uses a tariff to boost domestic output by raising the domestic producer price, but does not like taxing the users. Thus, it will wish to exempt users if it does not need to tax them in order to raise the domestic producer price, exactly as in the politics-only model.

Furthermore, this will yield similar patterns in tariff discrimination as under a politics-only model. More formally, this yields FOCs:

$$[\text{wrt } \tau_g]\ 0 = \frac{E_g'(y_g)\, e_{p_g}^{y_g}}{p_g} y_g + \tau_g \frac{M_g}{p_g} e_{p_g}^{M_g} + \sum_h (p_h - p_h^w) \frac{M_h}{p_g} e_{p_g}^{M_h}$$

$$[\text{wrt } \tau_{gh}]\ 0 = -E_g'(y_g) \frac{1}{p_g} e_{p_{gh}}^{x_{gh}} x_{gh} + \tau_g \frac{\partial M_g}{\partial p_{gh}} + \tau_{gh} \frac{\partial x_{gh}}{\partial p_{gh}}$$

$$[\text{wrt } p_h]\ 0 = \frac{E_h'(y_h)\, e_{p_h}^{y_h}}{p_h} y_h + \sum_g (1 - z_{gh}) \left[-E_g'(y_g) \frac{1}{p_g} e_{p_h}^{x_{gh}} x_{gh} + \tau_g \frac{\partial M_g}{\partial p_h} \right] + E_h'(y_h) \frac{\partial y_h}{\partial p_h} + (p_h - p_h^w) \frac{\partial M_h}{\partial p_h}$$

$$[\text{wrt } z_{gh}]\ 0 = E_g'(y_g) \frac{\partial y_g}{\partial z_{gh}} + \frac{\partial W}{\partial z_{gh}}$$

[4] I abstract from non-tariff barriers and quotas, and assume the government only can use tariffs. However, there is a long tradition of computing tariff equivalents to non-tariff barriers (see, e.g., Anderson and Neary (1994)). Similarly, quotas are well-known to have tariff equivalents in perfect competition models like this one as long as the government auctions off the licenses.

[5] There are exceptions in the GATT/WTO rules for agriculture, and for countries with a GNP per capita of less than $1,000 in 1990 dollars.

where there is a near isomorphism between political weights and local derivatives of the externality. Note that this is not exact: when moving industries to the lower tier the government may wish to boost their outputs (and so may place additional weights on some industries relative to the welfare gains of eliminating consumption distortions), but will not put an additional weight on transferring revenue to consumers. This is in contrast to politically-motivated tariff discrimination in which the government will put additional weight on both revenue transfers and on boosting output.

Appendix 2.3: Impact on upper-tier tariffs and aggregate imports:

In the main text, I characterize optimal tariff discrimination but do not discuss the implications of tariff discrimination (as opposed to uniform tariffs) for the level of upper tier tariffs or aggregate imports. In this section, I show that although the ability to discriminate may lead the government to set different upper-tier tariffs, the direction of the effect is ambiguous, as is the effect of SEZs on aggregate imports. Below I provide examples of settings in which the effects go in different directions.

All of the settings will share some common features: all will have only one imported intermediate, a continuum of length one of exported final goods, $g \in [0,1]$, and some shared parameters, namely that $p_h^w = 1$, $\lambda_h = 3$, $y_h = 1$, and $x_{gh} = 4 - p_{gh}\ \forall g$. These parameters imply that the optimal lower-tier tariff for all final goods will be 0, and the government's gain from moving a final good user to the lower tier will be the welfare gain, which is $-\frac{1}{2}\tau^2$, where τ is the upper-tier tariff.

First, I provide an example in which the ability to discriminate across users leads to a fall in the tariff. Suppose that $\lambda_g = 1\ \forall g$. In this case, the optimal uniform intermediate tariff is 2, while if the government can discriminate, then the optimal intermediate tariff is ≈ 1.72. Since the tariff is lower on all users in the discriminatory case relative to the uniform case, aggregate imports increase.

Second, I provide an example where the upper-tier tariff is higher, but aggregate import volumes nevertheless increase. Suppose that $\lambda_g = 1 + g\ \forall g$. In this case the optimal uniform tariff is 1, while if the government can discriminate the optimal upper-tier tariff is ≈ 1.33 (and is applied to approximately 60% of users). Under the uniform tariff import volumes are 1, while under discrimination, import volume is 1.2. Users at the upper tier now face a higher tariff but users at the lower tier face a lower tariff relative to the uniform case. In this particular example, the impact of lower tariffs on the lower tier users outweighs the effect of higher tariffs on the upper tier users.

In the third case, suppose that $\lambda_g = 2 + g\ \forall g$. In this case the optimal uniform intermediate tariff is 0, while under tariff discrimination the optimal upper tier tariff is ≈ 0.21, and only paid by $\approx 36\%$ of final goods firms. Clearly in this case import volumes must fall: tariffs on upper tier users increase relative to a uniform tariff while those on lower tier users are unchanged.

Appendix 2.4: Foreign and domestic goods are imperfect substitutes:

Throughout the paper, I use the assumption (common in the trade policy literature) that foreign and domestic varieties of a good are perfect substitutes, and this assumption is important to my results. However, much research in trade instead assumes that different countries have different varieties of a good and that these varieties are imperfect substitutes. In this section, I show that the theory presented in the body of the paper is robust to allowing domestic and foreign varieties to be imperfect substitutes.

I do so in an "ideal variety" setting in the style of Lancaster (1966), using a simplified version of the model in Helpman (1981). This can be taken as a generalization of a discrete choice framework; individual preferences of the discrete choice variety readily aggregate to a representative agent that displays love of variety (in particular, it is possible to microfound CES preferences in this way; see

Anderson, de Palma, and Thisse (1989)). An important caveat, however, is that the intuition in this paper does not carry through into settings in which *individual* agents have a love of variety. However, there is strong reason to believe that ideal variety models like this one accurately captures tariff discrimination: the enormous discrete choice literature was in part motivated by the observation that individual agents do not consume very small amounts of the enormous set of available goods, and instead consume discrete amounts of a comparatively few of them.

My aim is to show how the theory is consistent with imperfect substitutability of this type, rather than re-derive general results in the most general framework possible. Towards this end, I have made the setting stylized and parsimonious, analogous to the simple model presented in the text; the extension to more generalized settings should be clear based on the intuition here.

Suppose that there are two final goods – the numeraire, and a differentiated good, of which there are many possible "ideal" varieties. There are no intermediates, so discrimination will be across final goods consumers. Homogenous consumers with unit mass have an ideal variety of the differentiated good, $v \in [0, 1]$, which are distributed uniformly across that interval. Consumers have utility

$$u = x_0 + u\left(xh\left(|\hat{v} - v|\right)\right)$$

when consuming x units of variety $\hat{v}$, where $h(0)$=0, $h'(\cdot) \leq 0$, and $h(\cdot) > 0$. Only two varieties of the differentiated good are produced – a foreign variety and a domestic one (and WLOG I assume that the domestic variety has a smaller index than the foreign one and both lie on $[0, 1]$). I will make the (somewhat ad-hoc) assumption that foreign agents do not consume the domestic good and that domestic consumers cannot influence foreign prices (denoted p^w) to avoid considerations related to terms-of-trade manipulation.[6] I assume p^w (and the domestic production function) are such that some of the foreign variety is consumed in the absence of tariffs.

Consider a case with a less than prohibitive uniform tariff τ. Let us denote by c the variety considered ideal by the consumer who is exactly indifferent between buying the domestic and foreign variety. Equilibrium is characterized by a cutoff at c in demand, utility maximization, profit maximization, and market clearing for the domestically produced good. Those above the cutoff will import and consume the foreign variety in equilibrium, while those below will consume the domestic variety.

$$\begin{aligned}
p &= \frac{h(c)}{h(1-c)}\left[p^w + \tau\right] \\
u_i'\left(x(z)\,h(z)\right) &= \frac{p}{h(z)}\ \forall z \leq c \\
F_L^i(K_i, L_i) &= \frac{1}{p} \\
F^i\left(K_i, L_i\right) = x &= \int_0^c x(z)dz
\end{aligned}$$

The government can do strictly better with discrimination than under a uniform tariff – were the government to keep the tariff the same on agents with ideal variety in $[0, c]$ the same, while lowering the tariff to zero for other consumers, the market clearing conditions above would be unchanged. Thus, the government would induce exactly the same domestic producer surplus while eliminating some consumption distortion.

[6] I could alternatively avoid terms-of-trade considerations using the trick of Flam and Helpman (1987) if we think of profits not as capital quasi-rents but instead the profits of an exogenous number of domestic firms in the sector; I have not done so in order to keep the model as analogous that presented in the text as possible

Appendix 2.5: Production functions which aren't separable:

In the main text, I assume the production function for any final good g is constant returns to scale of the form $y_g = F^{gL}(K_g, L_g) + \sum_{h=1}^{H} F^{gh}(K_g, x_{gh})$ so that production is additively separable across all variable inputs. In this section, I show that the spirit of my results extends to a general setting in which production functions are not separable across variable inputs, i.e. that production of any final good g is constant returns to scale of the form $y_g = F^g(K_g, L_g, \vec{x}_g)$, where $\vec{x}_g = (x_{g1}, x_{g2}, \ldots, x_{gH})$. This setting does introduce some additional considerations for optimal policy, and in this setting the inverted tariff may not be the welfare-maximizing lower tier tariff.

The general flavor of the results presented in the main text is maintained under this production framework, although the details of some results now account for cross-elasticities between different intermediates. In particular, although there is still a two-tiered tariff result, now the lower tier accounts for cross-elasticities (and the optimal assignment is related to the tariff policy on other intermediate goods). This also means that the inverted tariff is not necessarily welfare maximizing, and so the inverted tariff is no longer an upper bound on the upper tier. All imports are consumed by industries assigned to the lower tier (as in the separable case) and follows from identical logic. Finally, which industries are assigned to the lower tier now takes into account the trade policy on other intermediates and the cross-elasticity between intermediates. However, the general characteristics of the solution are the same as the version in the main body of the text. I discuss each result below.

Two-tiered tariff system with a non-separable production function: I show that, for all g and h, the user-specific tariff is assigned to one of at most two tiers, and

$$\tau_{gh} \in \left\{ [0,\ \frac{\tau_g}{p_g^w} p_h^w + \frac{\tau_g}{p_g^w} \frac{\frac{\partial L}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}} - \sum_{j=1,\, j\neq h}^{H} \left(\frac{\tau_{gj} - \frac{\tau_g}{p_g^w} p_j^w}{p_g^w + \tau_g} \right) \frac{\frac{\partial x_{gj}}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}}],\ p_h - p_h^w \right\}$$

The derivation follows the separable case, with the exception of the FOC with respect to τ_{gh}. Due to cross-elasticities between intermediates, this FOC (for $\tau_{gh} \in (0, p_h - p_h^w)$) now becomes:

$$\begin{aligned} 0 \quad &= \quad \tau_g \frac{\partial M_g}{\partial \tau_{gh}} + \tau_{gh} \frac{\partial x_{gh}}{\partial \tau_{gh}} + \sum_{j=1,\, j\neq h}^{H} \tau_{gj} \frac{\partial M_j}{\partial \tau_{gh}} - (\lambda_g - 1)\, x_{gh} + \nu_h \frac{\partial x_{gh}^d (p_h,\, \tau_{gh}, \tau_g)}{\partial \tau_{gh}} \\ &\quad + \sigma_g \frac{\partial M_g}{\partial \tau_{gh}} \tau_g + \omega_{gh} + \sigma_{gh} M_h(p_h) \end{aligned}$$

Thus (assuming the trade policy choice never includes prohibitive tariffs), the solution to the FOC for τ_{gh} will satisfy

$$-\tau_{gh} \frac{\partial x_{gh}}{\partial \tau_{gh}} \quad = \quad -\tau_g \frac{\partial y_g}{\partial \tau_{gh}} + \sum_{j=1,\, j\neq h}^{H} \tau_{gj} \frac{\partial x_{gj}}{\partial \tau_{gh}} - (\lambda_g - 1)\, x_{gh}$$

Also due to cross-elasticities, the value of $\frac{\partial y_g}{\partial \tau_{gh}}$ becomes

$$\frac{\partial y_g}{\partial \tau_{gh}} \quad = \quad \frac{1}{p_g^w + \tau_g} \cdot \left[\frac{\partial L}{\partial \tau_{gh}} + \sum_{j=1}^{H} \left((p_j^w + \tau_{gj}) \cdot \frac{\partial x_{gj}}{\partial \tau_{gh}} \right) \right]$$

implying

$$\tau_{gh} = \frac{\tau_g}{p_g^w} p_h^w + \frac{\tau_g}{p_g^w} \frac{\frac{\partial L}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}} - \sum_{j=1,\, j\neq h}^{H} \left(\frac{\tau_{gj} - \frac{\tau_g}{p_g^w} p_j^w}{p_g^w + \tau_g} \right) \frac{\frac{\partial x_{gj}}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}}$$
$$+ (\lambda_g - 1)\, x_{gh} \left(1 + \frac{\tau_g}{p_g^w} \right) \frac{1}{\frac{\partial x_{gj}}{\partial \tau_{gh}}}$$

and thus

$$\tau_{gh} \in \left\{ [0,\ \frac{\tau_g}{p_g^w} p_h^w + \frac{\tau_g}{p_g^w} \frac{\frac{\partial L}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}} - \sum_{j=1,\, j\neq h}^{H} \left(\frac{\tau_{gj} - \frac{\tau_g}{p_g^w} p_j^w}{p_g^w + \tau_g} \right) \frac{\frac{\partial x_{gj}}{\partial \tau_{gh}}}{\frac{\partial x_{gj}}{\partial \tau_{gh}}}],\ p_h - p_h^w \right\}$$

Note that the tariff-setting rule (and intuition) for the upper-tier tariff is unchanged from the separable case.

Lower tier imports with a non-separable production function: If there are many small final goods industries, and for a given intermediate h, $p_h > p_h^w$ and $\lambda_h > 1$, then all imports of the intermediate h will be consumed by final goods firms facing the lower tier tariff. This is exactly the same as in the separable case, and stems from exactly the same logic: as long as there is any political motivation for the tariff, the resulting tariff level will be above the optimal level when intermediate producers have no political strength and so the government can always do better by lowering the tariff on enough using industries.

Industries preferred for the lower tier tariff with a non-separable production function: I show that as in the separable production function case, industries g that are politically strong and have a low ad-valorem equivalent final goods tariffs relative to other users of h,will be granted a lower-tier tariff for h. Furthermore, once production functions are not separable, users which face lower tariffs on intermediates which are stronger substitutes (in industry g's production function) and higher tariffs on intermediates which are stronger complements (in industry g's production function) will be granted a lower-tier tariff for h.

I simplify the exposition by using some new notation. In particular, define $q_{gh} \equiv z_{gh} (\tau_{gh} + p_h^w) + (1 - z_{gh})\, p_h$ for all g and h. This means that q_{gh} captures the price faced by industry g for h, so that I do not need additional notation to note that g may be at upper or lower tier for h. In a (mild) abuse of notation, I use $\vec{q}_{g,-h}$ to denote the price vector faced by final goods industries for all prices other than h, so that $\pi_g(\vec{q}_{g,-h}, \tau_{gh} + p_h^w) - \pi_g(\vec{q}_{g,-h}, p_h)$ is the gain in profits from lowering industry g to the lower-tier tariff on h while keeping all other prices fixed.

Using this notation, the Lagrangian is the same as before, but now the FOC with respect to z_{gh} is

$$0 = \lambda_g \frac{\partial \pi_g}{\partial z_{gh}} + \tau_g \frac{\partial M_g}{\partial z_{gh}} + \sum_{j=1,\, j\neq h}^{H} \left(q_{gj} - p_j^w \right) \frac{\partial x_{gj}}{\partial z_{gh}} - (p_h - p_h^w)\, x_{gh} \left(\vec{q}_{g,-h}, p_h \right)$$
$$+ \tau_{gh} x_{gh} \left(\vec{q}_{g,-h}, p_h^w + \tau_{gh} \right) - \mu_h \left(p_h - p_h^w \right) x_{gh} \left(\vec{q}_{g,-h}, p_h \right) - \sigma_{gh}^U + \sigma_{gh}^L$$

As before, I use a second-order approximation for $\frac{\partial \pi_g}{\partial z_{gh}}$, only now this expansion reflects interactions between the prices of different intermediates. Using identical logic, I now write the second-order approximation around the upper-tier policies for good h, and equilibrium prices for other goods (and where for simplicity, I denote values at upper tier policies with an overbar, and drop the notation for the prices at the over-barred variables). Again, I use Hotelling's lemma to simplify the derivatives of the profit function.

$$
\begin{aligned}
\pi_g(p'_g, \vec{q}_g) \approx\; & \overline{\pi} + \overline{y}_g \left(p'_g - p_g\right) + \frac{1}{2}\frac{\partial \overline{y}_g}{\partial p_g}\left(p'_g - p_g\right)^2 - \sum_{j=1,\, j\neq h}^{H} \overline{x}_{gj}\left(q'_{gj} - q_{gj}\right) \\
& - \sum_{k=1,\, k\neq h}^{H} \sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{x}_{gj}}{\partial p_k}\left(q'_{gj} - q_{gj}\right)\left(q'_{gk} - q_{gk}\right) + \frac{1}{2}\sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{x}_{gj}}{\partial p_j}\left(q'_{gj} - q_{gj}\right)^2 \\
& + \sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{y}_g}{\partial p_j}\left(p'_g - p_g\right)\left(q'_{gj} - q_{gj}\right) \\
& - \overline{x}_{gh}\left(q_{gh} - p_h\right) - \frac{1}{2}\frac{\partial \overline{x}_{gh}}{\partial p_h}\left(q_{gh} - p_h\right)^2 - \sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{x}_{gj}}{\partial p_h}\left(q'_{gj} - q_{gj}\right)\left(q_{gh} - p_h\right) \\
& + \frac{\partial \overline{y}_g}{\partial p_h}\left(p'_g - p_g\right)\left(q_{gh} - p_h\right)
\end{aligned}
$$

so that

$$
x_{gh}(p'_g, \vec{q}_g) \approx \overline{x}_{gh} - \frac{\partial \overline{x}_{gh}}{\partial p_h}\left(q_{gh} - p_h\right) - \sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{x}_{gj}}{\partial p_h}\left(q'_{gj} - q_{gj}\right) + \frac{\partial \overline{y}_g}{\partial p_j}\left(p'_g - p_g\right)
$$

and

$$
y_g(p'_g, \vec{q}_g) \approx \overline{y}_g + \frac{\partial \overline{y}_g}{\partial p_g}\left(p'_g - p_g\right) + \sum_{j=1,\, j\neq h}^{H} \frac{\partial \overline{y}_g}{\partial p_j}\left(q'_{gj} - q_{gj}\right) + \frac{\partial \overline{y}_g}{\partial p_h}\left(q_{gh} - p_h\right)
$$

I use this expression to simplify the FOC with respect to z_{gh}. Consequently

$$
\begin{aligned}
\frac{\partial \pi_g}{\partial z_{gh}} &\approx \overline{x}_{gh}\left(p_h - p^w_h - \tau_{gh}\right) + \frac{1}{2}\frac{\partial \overline{x}_{gh}}{\partial p_h}\left(p_h - p^w_h - \tau_{gh}\right)^2 \\
\frac{\partial M_g}{\partial z_{gh}} &\approx -\frac{\partial \overline{y}_g}{\partial p_h}\left(p_h - p^w_h - \tau_{gh}\right) \\
\frac{\partial x_{gj}}{\partial z_{gh}} &= \frac{\partial \overline{x}_{gh}}{\partial p_j}\left(p_h - p^w_h - \tau_{gh}\right)
\end{aligned}
$$

and also

$$
\begin{aligned}
\tau_{gh} x_{gh}\left(\vec{q}_{g,-h}, p^w_h + \tau_{gh}\right) - \left(p_h - p^w_h\right) x_{gh}\left(\vec{q}_{g,-h}, p_h\right) \approx\; & \left(\tau_{gh} + p^w_h - p_h\right)\overline{x}_{gh} \\
& - \tau_{gh}\frac{\partial \overline{x}_{gh}}{\partial p_h}\left(\tau_{gh} + p^w_h - p_h\right)
\end{aligned}
$$

so that I can simplify the FOC with respect to z_{gh} (again, using $t_i,\ i \in \{g, h\}$ to denote the ad-valorem equivalent of price wedges,

$$
\begin{aligned}
0 =\; & \lambda_g\left[\overline{x}_{gh}\left(p_h - p^w_h - \tau_{gh}\right) + \frac{1}{2}\frac{\partial \overline{x}_{gh}}{\partial p_h}\left(p_h - p^w_h - \tau_{gh}\right)^2\right] - \tau_g\frac{\partial \overline{y}_g}{\partial p_h}\left(p_h - p^w_h - \tau_{gh}\right) \\
& + \sum_{j=1,\, j\neq h}^{H}\left(q_{gj} - p^w_j\right)\frac{\partial \overline{x}_{gh}}{\partial p_j}\left(p_h - p^w_h - \tau_{gh}\right) + \left(\tau_{gh} + p^w_h - p_h\right)\overline{x}_{gh} \\
& - \tau_{gh}\frac{\partial \overline{x}_{gh}}{\partial p_h}\left(\tau_{gh} + p^w_h - p_h\right) - \mu_h\left(p_h - p^w_h\right) x_{gh}\left(\vec{q}_{g,-h}, p_h\right) - \sigma^U_{gh} + \sigma^L_{gh}
\end{aligned}
$$

which yields a final FOC with respect to z_{gh} of

$$\begin{aligned} 0 &= (\lambda_g - 1)\, p_h^w \left[t_h - t_{gh} + \frac{1}{2}\frac{(t_{gh} - t_h)^2}{1 + t_h} e_{p_h}^{x_{gh}} \right] + \frac{(t_h - t_{gh})(t_h - t_g)}{(1 + t_g)(1 + t_h)} p_h^w e_{p_h}^{x_{gh}} - \mu_h (p_h - p_h^w) \\ & -\sigma_{gh}^U + \sigma_{gh}^L - \sum_{j=1,\, j \neq h}^{H} \left(\frac{q_{gj}}{p_j^w} - 1 \right) (t_h - t_{gh})\, p_h^w e_{p_j}^{x_{gh}} \end{aligned}$$

It is relatively straightforward to show that this first order condition gives the stated result. The first five terms are shared with the FOC for a separable production function, and so imply the same result as in the separable case. The two additional forces which arise in the non-separable case follow immediately from the final term:

$$-\sum_{j=1,\, j \neq h}^{H} \left(\frac{q_{gj}}{p_j^w} - 1 \right) (t_h - t_{gh})\, p_h^w e_{p_j}^{x_{gh}}$$

Appendix 2.6: Large-country SEZ policy:

In the main text, I assume a small country; I relax this assumption in this section and consider a country with terms-of-trade power. The general flavor of results presented in the main text are preserved, but now policy on intermediate goods reflects terms of trade motives on both intermediate and final goods. However, a general two-tiered tariff system, all imports going through the lower tier, and the rough characteristics of industries preferred for the lower tier tariff are all consistent with the small-country case.

In the remainder of this section, I impose an additional simplifying assumption: that each good is produced using at most one intermediate (but each intermediate may be consumed by an arbitrary number of final goods industries). This greatly simplifies the problem while still preserving the flavor of how SEZ use reflects terms-of-trade considerations.[7] The advantage of this assumption is that it prevents terms-of-trade effects between intermediate goods, while still preserving terms-of-trade considerations between intermediates and final goods.[8]

In addition, I also assume all goods are imported for the remainder of this section. The reason for this assumption is that intermediate goods export taxes and final goods tariffs (or intermediate goods tariffs and final goods export taxes) are imperfect substitutes for manipulating the terms-of-trade. Consequently, there can be additional incentives to increase intermediate goods tariffs when export taxes on exported final goods which use the intermediate are not available (and increase final goods tariffs for final goods which use an exported intermediate when an export tax on the relevant intermediates is not available). The underlying intuition is actually the same as the intuition which I develop in a setting in which policy is available for all goods (and I will discuss this explicitly later), but considering this force explicitly significantly complicates the exposition and so ignore it in most of what follows.

[7] Note that this is consistent with needing assumptions to obtain tractable uniform tariffs in the presence of terms-of-trade manipulation. As McLaren (2016) notes, the standard inverse foreign export supply rule from Grossman and Helpman (1995b) arises from demands which are separable across goods, and does not extend to more general settings.

[8] If I did not make this assumption, a change to any tariff (either on a final good or on a $g-h$ pair) might change the world prices of all goods in the economy. For example, a change in one final goods tariff would change the world price of that good, in turn changing the demand for intermediates (and hence the prices of these goods), which in turn could affect the output (and prices) of other final goods. This leads to a large number of cross-elasticity terms which complicate the algebra and intuition.

Throughout, I also adopt some new notation which will simplify the proofs. First, I define G_h as the set of all final goods industries which consume intermediate h. By assumption, $G_h \cap G_{h'} = \emptyset$ for $h' \neq h$. Also, I define $p_{gh} \equiv \tau_{gh} + p_h^w$ (and similarly transform the constraints in the problem so that they are expressed in terms of p_{gh} rather than τ_{gh}), and then let the government choose the set of $\{p_{gh}\}$ rather than the set of $\{\tau_{gh}\}$ as I do in the body of the paper.

Under this additional assumption and using this new notation, I then discuss how the small country results change in this framework. The results are rather dense, so I start by building intuition in simplified settings. In particular, I first develop intuition in a setting with terms-of-trade power in intermediate markets but not final goods markets, initially in the absence of politics and then considering politics as well. Second, I present analogous work for a setting with terms-of-trade power in final goods markets but not intermediates markets. Third, I present results when the country has terms-of-trade power in all goods, but no politics. And finally, I present analogous results for the propositions in the text in a setting with terms-of-trade power and politics.

Terms-of-trade power only in intermediate goods: In this section, I outline optimal policy in a setting in which a country only has terms-of-trade power in intermediate goods. In this section, I show that terms-of-trade power of this form does not give new motivations to discriminate with tariffs per se. The additional consideration in the government objective will change optimal policies, but not in a way which changes the intuition from the results in the main text.

First, in the case that there are no politics (i.e., $\lambda_i = 1\ \forall\, i \in \{g, h\}$), then the government will not wish to discriminate with tariffs. I start with international market clearing (note that I use E_i to denote foreign exports of good i which may be negative if the rest of the world is an importer). The market clearing conditions relevant to intermediate h is

$$E_h\left(p_h^w, \vec{p}^{\,w}_{G_h}\right) = M_h\left(p_{h,G_h}, \vec{p}_{G_h}\right)$$

where by $\vec{p}^{\,w}_{G_h}$ and $\vec{p}_{G_h}$ I mean a vector of world and domestic final goods prices for $g \in G_h$ and by $\vec{p}_{h,G_h}$ I denote the intermediate price faced by all final goods industries.

These equations yield the following useful derivative with respect to some price $n \in \{p_h, p_{gh}, p_g\}$

$$\frac{\partial E_h}{\partial p_h^w}\frac{\partial p_h^w}{\partial n} = \frac{\partial M_h}{\partial n}$$

where note that I can ignore the impact on the world prices of all goods g and on market clearing in final goods per the assumption that home is small in all final goods markets.

And the FOCs for optimal prices (dropping Lagrange multipliers for clarity, although I will appeal to them informally) when combined with the derivatives of the intermediate import market clearing condition are

$$[\text{wrt } p_g,\ g \in G_h]\ 0 = \tau_g \frac{\partial M_g}{\partial p_g} + \left(\tau_{gh} - \frac{M_h}{\frac{\partial E_h}{\partial p_h^w}}\right)\frac{\partial M_h}{\partial p_g}$$

$$[\text{wrt } p_{gh},\ g \in G_h,\ z_{gh} = 1]\ 0 = \tau_g \frac{\partial M_g}{\partial p_{gh}} + \left(\tau_{gh} - \frac{M_h}{\frac{\partial E_h}{\partial p_h^w}}\right)\frac{\partial M_h}{\partial p_{gh}}$$

$$[\text{wrt } p_h]\ 0 = \sum_{g \in G_h}(1 - z_{gh})\tau_g \frac{\partial M_g}{\partial p_h} + \left[(p_h - p_h^w) - \frac{M_h}{\frac{\partial E_h}{\partial p_h^w}}\right]\frac{\partial M_h}{\partial p_h}$$

Thus, all final goods tariffs are zero (since $\tau_{gh} - \frac{M_h}{\frac{\partial E_h}{\partial p_h^w}} = 0$ from the FOC with respect to intermediate goods policy so that the FOC with respect to τ_g is strictly negative), and all intermediates users are charged the same tariff rate, even though the government may discriminate. This result is intuitive: the only reason to use a tariff is to manipulate the world price of the intermediate good, and the most efficient instrument to do that is an intermediate good tariff. There is no reason to discriminate as consumption of an additional unit of the intermediate affects the world price in the same way, regardless of the user; thus, all users optimally face the same tariff.

Second, in the case in which politics may also play a role in tariffs, the addition of terms-of-trade power in intermediates adds a terms-of-trade component to optimal tariff policy. I now present the FOCs when politics are present combined with the derivatives of the import market clearing condition:

$$[\text{wrt } p_g,\ g \in G_h]\ 0 = (\lambda_g - 1)\, y_g + \tau_g \frac{\partial M_g}{\partial p_g} + \left(\tau_{gh} - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}}\right) \frac{\partial M_h}{\partial p_g}$$

$$[\text{wrt } p_{gh},\ g \in G_h,\ z_{gh} = 1]\ 0 = -\,(\lambda_g - 1)\, x_{gh} + \tau_g \frac{\partial M_g}{\partial p_{gh}} + \left(\tau_{gh} - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}}\right) \frac{\partial M_h}{\partial p_{gh}}$$

$$[\text{wrt } p_h]\ 0 = (\lambda_h - 1)\, y_h + \sum_{g \in G_h} (1 - z_{gh}) \left[-\,(\lambda_g - 1)\, x_{gh} + \tau_g \frac{\partial M_g}{\partial p_h}\right] + \left[(p_h - p_h^w) - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}}\right] \frac{\partial M_h}{\partial p_h}$$

$$[\text{wrt } z_{gh}]\ 0 = \lambda_g \frac{\partial \pi_g}{\partial z_{gh}} + \tau_g \frac{\partial M_g}{\partial z_{gh}} + \left(\tau_{gh} - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}}\right) \left[x_{gh}(p_g, p_{gh}) - x_{gh}(p_g, p_h)\right]$$

where in the final equation, I use the fact that

$$\begin{aligned}
\frac{\partial p_h^w}{\partial z_{gh}} &= \frac{\frac{\partial M_h}{\partial z_{gh}}}{\frac{\partial E_h}{\partial p_h^w}} \\
&= \frac{x_{gh}(p_g, p_{gh}) - x_{gh}(p_g, p_h)}{\frac{\partial E_h}{\partial p_h^w}}
\end{aligned}$$

As these FOCs make clear, the terms-of-trade incentive increases both upper-tier and lower-tier tariffs in the same way. Furthermore, second-best considerations related to intermediate tariffs will only affect final goods tariffs insofar as these tariffs deviate from the optimal terms-of-trade tariffs (i.e. $\tau_{gh} - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}} \neq 0$). This is exactly the same second-best consideration as in the small country case: the government wishes to spread the distortion from politically motivated tariffs across as many industries as possible. However, now the welfare maximizing tariff sets $\tau_{gh} = \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}}$ instead of zero, so the distortion to be spread out is related to the deviation of τ_{gh} from this optimum.

Furthermore, the choice of which industries obtain lower tier tariffs will reflect terms-of-trade considerations through second-best considerations (the deviation of intermediate tariffs from the optimal terms-of-trade tariffs, i.e. $\tau_{gh} - \frac{E_h}{\frac{\partial E_h}{\partial p_h^w}} \neq 0$). This is analogous to the second-best considerations for which industries obtain lower-tier tariffs as discussed in Proposition 2. This may change the precise considerations of the government but will not overturn the results of Proposition 4, as can be shown by substituting in FOCs with respect to p_{gh} into the FOC with respect to z_{gh}.[9]

$$0 = (\lambda_g - 1)\left(\frac{\partial \pi_g}{\partial z_{gh}} - x_{gh}\left[\frac{x_{gh}(p_g, p_{gh}) - x_{gh}(p_g, p_h)}{-\frac{\partial x_{gh}(p_g, p_{gh})}{\partial p_{gh}}}\right]\right) + \tau_g\left(\frac{\partial M_g}{\partial z_{gh}} + \frac{p_{gh}}{p_g}\left[x_{gh}(p_g, p_{gh}) - x_{gh}(p_g, p_h)\right]\right) + \frac{\partial \pi_g}{\partial z_{gh}}$$

And this formulation makes clear that the flavor of the results in the main text will carry through even after terms-of-trade considerations are included in intermediates.

Terms-of-trade power only in final goods: The results in this section are largely analogous to those when the country only has terms-of-trade power in intermediate goods. Again, the addition of this terms-of-trade power does not give new motivations to discriminate. The addition of terms-of-trade power will change optimal policies, but not in a way which changes the intuition from the results in the main text.

First, in the case with no political forces, all terms-of-trade considerations will be targeted via final goods tariffs, and there will be no tariff discrimination (or intermediate trade policy at all). The market clearing conditions relevant to final good $g \in G_h$ is

$$E_g\left(p_h^w, p_g^w\right) = M_g\left(p_{gh}, p_g\right)$$

which yields the following useful derivative with respect to some price $n \in \{p_h, p_{gh}, p_g\}$

$$\frac{\partial E_g}{\partial p_g^w}\frac{\partial p_g^w}{\partial n} = \frac{\partial M_g}{\partial n}$$

where note that I can ignore the impact on the world prices of h market clearing in intermediate goods per the assumption that home is small in all intermediate goods markets.

And the FOCs for optimal prices (dropping Lagrange multipliers for clarity, although I will appeal to them informally)combined with the derivatives of the intermediate import market clearing condition yield:

$$[\text{wrt } p_g,\ g \in G_h]\ 0 = \tau_{gh}\frac{\partial M_h}{\partial p_g} + \left(\tau_g - \frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial p_g}$$

$$[\text{wrt } p_{gh},\ g \in G_h,\ z_{gh} = 1]\ 0 = \tau_{gh}\frac{\partial M_h}{\partial p_{gh}} + \left(\tau_g - \frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial p_{gh}}$$

$$[\text{wrt } p_h]\ 0 = \sum_{g \in G_h}(1 - z_{gh})\left[\tau_g - \frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right]\frac{\partial M_g}{\partial p_h} + (p_h - p_h^w)\frac{\partial M_h}{\partial p_h}$$

The optimal intermediate goods policy will always be zero (and thus, there will be no discrimination), as final goods terms-of-trade considerations are most efficiently addressed via final goods policies. In particular, using the FOC with respect to the final goods policy, we establish that the first-order conditions with respect to p_{gh} and p_h are strictly negative, so that all intermediate tariffs are zero final goods tariffs are set such that $\tau_g = \frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}$.

[9] In this simplified setting in which each final good uses only one intermediate, it is also possible to pursue a similar strategy to eliminate τ_g and relate the choice of which industries obtain lower tier tariffs to the characteristics influencing final goods tariffs. I do not do this here as this is not possible in the more general setting of the main text, and so the resul would not be analogous.

Second, in the case in which politics may also play a role in tariffs, the addition of terms-of-trade power in intermediates adds a terms-of-trade component to optimal tariff policy. I now present the FOCs when politics are present; however, now there will be two tiers of tariff and so I include the FOC with respect to z_{gh}; these can again be combined with the derivatives of the international market-clearing conditions:

$$[\text{wrt } p_g,\ g\in G_h]\ 0=(\lambda_g-1)\,y_g+\tau_{gh}\frac{\partial M_h}{\partial p_g}+\left(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial p_g}$$

$$[\text{wrt } p_{gh},\ g\in G_h,\ z_{gh}=1]\ 0=-(\lambda_g-1)\,x_{gh}+\tau_{gh}\frac{\partial M_h}{\partial p_{gh}}+\left(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial p_{gh}}$$

$$[\text{wrt } p_h]\ 0=(\lambda_h-1)\,y_h+\sum_{g\in G_h}(1-z_{gh})\left[-(\lambda_g-1)\,x_{gh}+\left(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial p_h}\right]+(p_h-p_h^w)\,\frac{\partial M_h}{\partial p_h}$$

$$[\text{wrt } z_{gh}]\ 0=\lambda_g\frac{\partial \pi_g}{\partial z_{gh}}+\left(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\frac{\partial M_g}{\partial z_{gh}}-(p_h-p_h^w)\,x_{gh}(p_g,p_h)+\tau_{gh}x_{gh}(p_g,p_{gh})$$

Again, the impact of terms-of-trade considerations on intermediate goods policy comes through second-best considerations, as these tariffs now reflect the deviation of final goods policy from the welfare-maximizing policy $(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}})$ which incorporates terms-of-trade considerations. Again, this is exactly the same second-best consideration as in the small country case: the government wishes to spread the distortion from politically motivated tariffs across as many industries as possible.

Furthermore, the choice of which industries obtain lower tier tariffs will reflect terms-of-trade considerations through second-best considerations (the deviation of intermediate tariffs from the optimal terms-of-trade tariffs, i.e. $\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\neq 0$). This is analogous to the second-best considerations for which industries obtain lower-tier tariffs as discussed in Proposition 2. This may change the precise considerations of the government but will not overturn the results of Proposition 4, as can be shown by substituting in FOCs with respect to p_{gh} into the FOC with respect to z_{gh}.[10]

$$0=(\lambda_g-1)\left(\frac{\partial \pi_g}{\partial z_{gh}}+x_{gh}\frac{x_{gh}}{\frac{\partial x_{gh}}{\partial p_{gh}}}\right)+\left(\tau_g-\frac{E_g}{\frac{\partial E_g}{\partial p_g^w}}\right)\left(\frac{\partial M_g}{\partial z_{gh}}+\frac{p_{gh}}{p_g}x_{gh}(p_g,p_h)\right)-(p_h-p_h^w)\,x_{gh}(p_g,p_h)+\frac{\partial \pi_g}{\partial z_{gh}}$$

And this formulation makes clear that the flavor of the results in the main text will carry through even after terms-of-trade considerations are included in intermediates.

Two-tiered tariff system with terms-of-trade-power: Now I move to a setting in which there are politics and the country potentially has terms-of-trade power in all markets. I show under reasonable conditions that, as in the small-country case, there is a general two-tiered tariff system, but now the lower tier tariff additionally reflects terms-of-trade considerations. As I show below,

$$\tau_{gh}\in\left\{[0,\ \frac{p_g^w p_h^w+\tau_g p_h^w-\alpha_h\frac{\partial p_h^w}{\partial M_h}p_g}{1+\frac{\partial p_g^w}{\partial M_g}\left(\alpha_h\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h}-M_g\right)}-p_h^w],\ p_h-p_h^w\right\}$$

[10] In this simplified setting in which each final good uses only one intermediate, it is also possible to pursue a similar strategy to eliminate τ_g and relate the choice of which industries obtain lower tier tariffs to the characteristics influencing final goods tariffs. I do not do this here as this is not possible in the more general setting of the main text, and so the resul would not be analogous.

where α_h (defined formally, below) reflects how a change in the price of the intermediate impacts the government's objective. Unsurprisingly, lower tier tariffs will be larger when the government is hurt by an increase in the intermediate good's price (and will be lower when the government is helped by such an increase, which is possible if this induces changes in the world prices of the using industries which are sufficiently large so as to offset the direct impacts of a higher price of the imported intermediate). The difference from the small-country case will be larger when the world price of h is particularly sensitive to increases in demand, when the world supply of h is more affected by changes in the world price of g, and when the world price of g is particularly sensitive to increases in supply of g. I provide a derivation below, in which I solve for the above derivatives in terms of derivatives of foreign export supplies and import demands (although these results are not particularly illuminating).

The logic follows that for a small country (as presented in the text and proved in Appendix 1), with the exception of the FOC with respect to τ_{gh} (i.e., p_{gh} following the new notation). Accounting for terms-of-trade power, the FOC with respect to p_{gh} (for $p_{gh} \in (p_h^w, p_h)$) implies (relative to the FOC for a small country, $\frac{\partial \Omega^{small}}{\partial p_{gh}}$):

$$\begin{aligned} 0 &= \frac{\partial \Omega}{\partial p_{gh}} \\ &= \frac{\partial \Omega^{small}}{\partial p_{gh}} + \frac{\partial \Omega}{\partial p_h^w}\frac{\partial p_h^w}{\partial p_{gh}} + \sum_{j \in G_h} \frac{\partial \Omega}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_{gh}} \\ &= \frac{\partial \Omega^{small}}{\partial p_{gh}} + \left(\frac{\partial \Omega}{\partial p_h^w} + \sum_{j \in G_h} \frac{\partial \Omega}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w} \right) \left[\frac{\partial p_h^w}{\partial M_h}\frac{\partial M_h}{\partial p_{gh}} + \frac{\partial p_h^w}{\partial M_g}\frac{\partial M_g}{\partial p_{gh}} \right] + \frac{\partial \Omega}{\partial p_g^w} \left[\frac{\partial p_g^w}{\partial M_g}\frac{\partial M_g}{\partial p_{gh}} \right] \end{aligned}$$

What this expression formalizes is that the lower tier tariff on a $g-h$ pair potentially changes the world prices of the intermediate and all $j \in G_h$. However, goods $j \neq g$ are only affected indirectly, via changes in the world price of the intermediate induced by the $g-h$ tariff. The world market for good g is influenced both directly (through change's in home's output) and indirectly through changes in the world price of the intermediate.

One complication which arises when countries are large and cannot use export instruments is that terms-of-trade manipulation can have both political and welfare consequences. More concretely,

$$\frac{\partial \Omega}{\partial p_j^w} = -M_j + \mathbf{1}\left(M_j < 0\right)\left(\lambda_j - 1\right) y_j$$

which also leads to a discontinuity at $M_j = 0$ (which I ignore in the rest of this discussion as it does not significantly change the intuition). Note that as the intermediate must be imported for the government to use $g-h$ tariffs in the first place, we know that $M_h \geq 0$ so that $\frac{\partial \Omega}{\partial p_h^w} = M_h$.

To be concise, I define

$$\alpha_h \equiv \frac{\partial \Omega}{\partial p_h^w} + \sum_{j \in G_h} \frac{\partial \Omega}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}$$

This captures how manipulation of the intermediate market in question affects the government's objective. Although it would be easy enough to solve this expression in terms of equilibrium relationships, this does not yield any additional insight: based on the final goods in question, increasing the world price of the intermediate may or may not be rewarding for the government. And given the stylized setup of the problem, it seems unlikely that the resulting predictions could be taken to the data.

I solve for the remaining terms directly using the equations for international market clearing (where E_i is the foreign exports of good i, $i \in \{g, h\}$): $\vec{M}(\vec{p}) = \vec{E}(\vec{p^w})$. First, the impact of changing demand for the intermediate (where I assume all $j \in G_h$)

$$\begin{aligned}
1 &= \frac{\partial E_h}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} + \sum_{j\in G_h}\frac{\partial E_h}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} \\
(M_j \geq 0)\ 0 &= \frac{\partial E_j}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} + \frac{\partial E_j}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} \\
(M_j < 0)\ \frac{\partial M_j}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} &= \frac{\partial E_j}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h} + \frac{\partial E_j}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_h}
\end{aligned}$$

(note that the last equation is necessary as when the final good is exported, the domestic price is the world price and so a change in the world price affects both world and domestic markets). I can combine these equations to find

$$\frac{\partial p_h^w}{\partial M_h} = \frac{1}{\frac{\partial E_h}{\partial p_h^w} + \sum_{j\in G_h}\frac{\partial E_h}{\partial p_j^w}\frac{\frac{\partial E_j}{\partial p_h^w}}{\mathbf{1}(M_j<0)\frac{\partial M_j}{\partial p_j^w} - \frac{\partial E_j}{\partial p_j^w}}}$$

And next, the impact of changing supply of the final good on intermediate prices

$$\begin{aligned}
0 &= \frac{\partial E_h}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_g} + \sum_{j\in G_h}\frac{\partial E_h}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_g} + \frac{\partial E_h}{\partial p_g^w}\frac{\partial p_g^w}{\partial M_g} \\
1 &= \frac{\partial E_g}{\partial p_h^w}\frac{\partial p_h^w}{\partial M_g} + \frac{\partial E_g}{\partial p_g^w}\frac{\partial p_g^w}{\partial M_g}
\end{aligned}$$

which yields

$$\begin{aligned}
\frac{\partial p_g^w}{\partial M_g} &= \frac{1}{\frac{\partial E_g}{\partial p_g^w} - \frac{\partial p_h^w}{\partial M_h}\frac{\partial E_g}{\partial p_h^w}\frac{\partial E_h}{\partial p_g^w}} \\
\frac{\partial p_h^w}{\partial M_g} &= -\frac{\partial p_g^w}{\partial M_g}\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h}
\end{aligned}$$

so that

$$\frac{\partial p_g^w}{\partial M_g}\frac{\partial M_g}{\partial p_{gh}} = -\frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial x_{gh}}{\partial p_{gh}}$$

which yields the impact of p_{gh} on the objective function via its influence on world prices

$$\begin{aligned}
\frac{\partial \Omega}{\partial p_{gh}} - \frac{\partial \Omega^{small}}{\partial p_{gh}} =& \alpha_h\left[\frac{\partial p_h^w}{\partial M_h}\frac{\partial x_{gh}}{\partial p_{gh}} + \frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h}\frac{\partial x_{gh}}{\partial p_{gh}}\right] - \frac{\partial \Omega}{\partial p_g^w}\left[\frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial x_{gh}}{\partial p_{gh}}\right] \\
=& \left[\alpha_h\frac{\partial p_h^w}{\partial M_h} + \frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\left(\alpha_h\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h} - \frac{\partial \Omega}{\partial p_g^w}\right)\right]\frac{\partial x_{gh}}{\partial p_{gh}}
\end{aligned}$$

This can be combined with the steps from the small country case to solve for the optimal p_{gh}

$$0 = \frac{\tau_{gh} p_g^w}{p_g} \frac{\partial x_{gh}}{\partial p_{gh}} - \frac{\tau_g p_h^w}{p_g} \frac{\partial x_{gh}}{\partial p_{gh}} - (\lambda_g - 1) x_{gh}$$
$$+ \left[\alpha_h \frac{\partial p_h^w}{\partial M_h} + \frac{p_{gh}}{p_g} \frac{\partial p_g^w}{\partial M_g} \left(\alpha_h \frac{\partial E_h}{\partial p_g^w} \frac{\partial p_h^w}{\partial M_h} - \frac{\partial \Omega}{\partial p_g^w} \right) \right] \frac{\partial x_{gh}}{\partial p_{gh}}$$
$$p_{gh} = \frac{p_g^w p_h^w + \tau_g p_h^w - \alpha_h \frac{\partial p_h^w}{\partial M_h} p_g}{1 + \frac{\partial p_g^w}{\partial M_g} \left(\alpha_h \frac{\partial E_h}{\partial p_g^w} \frac{\partial p_h^w}{\partial M_h} - \frac{\partial \Omega}{\partial p_g^w} \right) + (\lambda_g - 1) p_g \frac{1}{e_{p_{gh}}^{x_{gh}}}}$$

It turns out p_{gh} is strictly decreasing in λ_g under reasonable assumptions (these assumptions are necessary as there is a λ_g buried in $\frac{\partial \Omega}{\partial p_g^w}$). In particular, we need that, if g is exported, the terms-of-trade impact of the lower-tier tariff is not so strong that it outweighs the increase in profits stemming from the lower input price; this situation is a sort of analogue of Metzler's Paradox. It is relatively simple to show that the analogues conditions deliver the same result: that world export demand of good g has a sufficiently large own-world-price elasticity than the price-elasticity of intermediate use by industry g (and some cross-elasticities in world export supply). If I make these assumptions, then I can simplify (note that, per this assumption $-\frac{\partial \Omega}{\partial p_g^w} \frac{\partial p_g^w}{\partial M_g} + (\lambda_g - 1) p_g \frac{1}{e_{p_{gh}}^{x_{gh}}} \geq M_g$ and will be equal when $\lambda_g = 1$):

$$p_{gh} \leq \frac{p_g^w p_h^w + \tau_g p_h^w - \alpha_h \frac{\partial p_h^w}{\partial M_h} p_g}{1 + \frac{\partial p_g^w}{\partial M_g} \left(\alpha_h \frac{\partial E_h}{\partial p_g^w} \frac{\partial p_h^w}{\partial M_h} - M_g \right)}$$

so that, if assigned to the lower tier,

$$\tau_{gh} \in [0, \frac{p_g^w p_h^w + \tau_g p_h^w - \alpha_h \frac{\partial p_h^w}{\partial M_h} p_g}{1 + \frac{\partial p_g^w}{\partial M_g} \left(\alpha_h \frac{\partial E_h}{\partial p_g^w} \frac{\partial p_h^w}{\partial M_h} - M_g \right)} - p_h^w]$$

Lower tier imports with terms-of-trade power: If there are many small final goods industries, and for a given intermediate h, $p_h > p_h^w$ and $\lambda_h > 1$, then all imports of the intermediate h will be consumed by final goods firms facing the lower tier tariff. This is exactly the same as in the small country case, and stems from exactly the same logic: as long as there is any political motivation for the tariff, the resulting tariff level will be above the optimal level when intermediate producers have no political strength and so the government can always do better by lowering the tariff on enough using industries.

Industries preferred for the lower tier tariff with terms-of-trade power: I show under reasonable conditions that, as in the small country case, using industries that are politically strong and have low ad-valorem equivalent final goods tariffs relative to other users of h will be preferred for lower-tier tariffs on h. Further, there are two additional forces for a large country: final goods industries for which the final good is imported and for which the inverse foreign own-world-price export supply is relatively inelastic will receive lower-tier tariffs on intermediate h.

To develop this intuition, I adopt the notation and strategy from earlier in the appendix (where I discuss two-tiered tariffs for a large country). I start by deriving the changes to the Lagrangian which occur when a country is large, and I exploit the same notation and framing as I use when discussing the two-tiered result with terms-of-trade power. This leads to a FOC with respect to z_{gh} (where I use $\frac{\partial \mathcal{L}^{Small}}{\partial z_{gh}}$ to denote the derivative of the Lagrangian in the small-country case):

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial z_{gh}} &= \frac{\partial \mathcal{L}^{Small}}{\partial z_{gh}} + \frac{\partial \Omega}{\partial p_h^w}\frac{\partial p_h^w}{\partial z_{gh}} + \sum_{j\in G_h}\frac{\partial \Omega}{\partial p_j^w}\frac{\partial p_j^w}{\partial z_{gh}} \\ &= \frac{\partial \mathcal{L}^{Small}}{\partial z_{gh}} + \left(\frac{\partial \Omega}{\partial p_h^w} + \sum_{j\in G_h}\frac{\partial \Omega}{\partial p_j^w}\frac{\partial p_j^w}{\partial p_h^w}\right)\left[\frac{\partial p_h^w}{\partial M_h}\frac{\partial M_h}{\partial z_{gh}} + \frac{\partial p_h^w}{\partial M_g}\frac{\partial M_g}{\partial z_{gh}}\right] + \frac{\partial \Omega}{\partial p_g^w}\left[\frac{\partial p_g^w}{\partial M_g}\frac{\partial M_g}{\partial z_{gh}}\right]\end{aligned}$$

If I follow (nearly) exactly the same steps from earlier in the appendix and use the same notation, I obtain

$$\frac{\partial p_h^w}{\partial M_h}\frac{\partial M_h}{\partial z_{gh}} + \frac{\partial p_h^w}{\partial M_g}\frac{\partial M_g}{\partial z_{gh}} = (p_h - p_{gh})\left[1 + \frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial E_h}{\partial p_g^w}\right]\frac{\partial p_h^w}{\partial M_h}\frac{\partial x_{gh}}{\partial p_{gh}}$$

$$\frac{\partial p_g^w}{\partial M_g}\frac{\partial M_g}{\partial z_{gh}} = -(p_h - p_{gh})\frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial x_{gh}}{\partial p_{gh}}$$

which yields impact of z_{gh} on the objective function via its influence on world prices

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial p_{gh}} - \frac{\partial \mathcal{L}^{small}}{\partial p_{gh}} =&(p_h - p_{gh})\left(\alpha_h\left[\frac{\partial p_h^w}{\partial M_h}\frac{\partial x_{gh}}{\partial p_{gh}} + \frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h}\frac{\partial x_{gh}}{\partial p_{gh}}\right] - \frac{\partial \Omega}{\partial p_g^w}\left[\frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial x_{gh}}{\partial p_{gh}}\right]\right) \\ =&(p_h - p_{gh})\left[\alpha_h\frac{\partial p_h^w}{\partial M_h} + \frac{p_{gh}}{p_g}\frac{\partial p_g^w}{\partial M_g}\left(\alpha_h\frac{\partial E_h}{\partial p_g^w}\frac{\partial p_h^w}{\partial M_h} - \frac{\partial \Omega}{\partial p_g^w}\right)\right]\frac{\partial x_{gh}}{\partial p_{gh}}\end{aligned}$$

so that

$$\begin{aligned}\frac{1}{p_h^w x_{gh}}\frac{\partial \mathcal{L}}{\partial z_{gh}} =&\frac{1}{p_h^w x_{gh}}\frac{\partial \mathcal{L}^{small}}{\partial p_{gh}} + \frac{1}{p_g^w p_h^w}\left(\frac{p_g^w}{1+t_{gh}} + \frac{p_h^w}{1+t_g}\frac{\partial p_g^w}{\partial M_g}\frac{\partial E_h}{\partial p_g^w}\right)e_{p_{gh}}^{x_{gh}}(t_h - t_{gh})\,\alpha_h\frac{\partial p_h^w}{\partial M_h} \\ &- \frac{t_h - t_{gh}}{1+t_g}\frac{e_{p_{gh}}^{x_{gh}}}{p_g^w}\frac{\partial p_g^w}{\partial M_g}\frac{\partial \Omega}{\partial p_g^w}\end{aligned}$$

Under some additional assumptions, the impact of output industry political weight and output tariff will be the same as in the small-country case. These assumption are that $\frac{\partial p_g^w}{\partial M_g}$ is sufficiently small relative to other terms (which is delivered if foreign export supply of g has a sufficiently large own-world-price elasticity) and $\frac{\partial p_h^w}{\partial M_h}$ is sufficiently small relative to other terms (which is delivered if foreign export supply of h has a sufficiently large own-world-price elasticity). The reason for the first assumption is that if g is exported then $\frac{\partial \Omega}{\partial p_g^w}$ is more negative with a greater political weight (as in the lower-tier result with terms of trade, the problem is a potential analogue of the Metzler Paradox). The reason for the second assumption is that if α_h is negative, the payout to a lower t_g may be negative; this assumption means that this force will be weaker than the small-country effect of a decrease in t_g.

Under a third assumption, that $\frac{\partial p_h^w}{\partial M_h}$ is small relative to $\frac{\partial p_g^w}{\partial M_g}$ (which is delivered if foreign export supply of h has a sufficiently large own-world-price elasticity relative to the own-world-price elasticity of foreign export supply of g), SEZs are more likely for imported final goods g, and this effect will be stronger when the own-price-elasticity of export supply of good g is relatively inelastic. This result comes immediately from the second term related to terms-of-trade-manipulation. It is natural to focus on this second term, as the first term is largely shared across all users of h while the second term is almost completely different for every possible user g. The (previously discussed) assumption that $\frac{\partial p_h^w}{\partial M_h}$ is sufficiently small relative to $e_{p_{gh}}^{x_{gh}}$ makes the first term related to terms-of-trade manipulation term relatively small, so that the main impact comes from the second term.

Appendix 2.7: Upper-tier imports:

In the text, I make simplifying assumptions to neatly characterize which users are assigned to lower-tier tariffs on a given input. In particular, I assume a continuum of small users for every intermediate, and that prevention of arbitrage is free. This leads to the prediction that all imports enter through lower tier tariffs. In this section, I show that there will be some imports through the upper tier if granting tariff reductions is costly or firms are large. (If using industries are large, there could also be imports at the upper tier, but this problem is NP-hard and so I cannot make further progress.)

Suppose there is a cost to granting tariff reductions for final good industry g on intermediate h equal to $c_{gh}\left(p_{gh}-p_h\right)$ where $c_{gh}\geq 0$ is a constant. This captures the idea that arbitrage may be more costly to prevent as it becomes more profitable. Once I account for these monitoring costs, the marginal impact on the government's objective for a lower-tier tariff (should the government assign a using industry to the lower tier) is

$$\frac{\partial\Omega}{\partial\tau_{gh}}=c_{gh}-\left(\lambda_g-1\right)x_{gh}+\tau_g\frac{p_h}{p_g}\frac{\partial x_{gh}}{\partial\tau_{gh}}+\tau_{gh}\frac{\partial x_{gh}}{\partial\tau_{gh}}$$

Once the FOC with respect to a lower-tier tariff has been adjusted in this way, then Proposition 3 does not hold, as it is easy to find a set of $\{c_{gh}\}$ which are sufficiently large (trivially, if these costs are infinite but in equilibrium there is a positive but less than prohibitive uniform intermediate goods tariff, then all imports will enter through the upper-tier). However, the exact share of imports entering through the upper tier will depend on the full set of $\{c_{gh}\}$ and the full characteristics of the equilibrium.

Second, if using industries are lumpy, it is possible that the optimum will involve imports through the upper tier. Unfortunately, characterizing optimal policy when using industries are lumpy is an NP-hard problem, as explained in the main text. Consequently, while I suspect this acts as a constraint on the share of imports which can enter at lower tier tariffs, I do not consider this explanation more formally. The intuition, however, is that the government might wish to move only part of a large firm or industry to the lower tier, but if it is unable to split things this way, may choose to leave some imports at the upper tier.

Appendix 3: Stylized facts

In this appendix, I provide additional facts about the U.S. SEZ program to supplement those in the main text. This appendix includes details of how the U.S. program operates applies tariff rates (Appendix 3.1), the history of the U.S. program (Appendix 3.2), and a comparison of U.S. SEZs to those in other developed countries (Appendix 3.3).

Appendix 3.1: Details of tariff application in U.S. SEZs

As I discuss in the text, U.S. SEZs permit importers to pay the "inverted tariff" on eligible intermediates, i.e. the tariff applicable to the final good will be applied to the value of the intermediate. In order to understand the inverted tariff and the limitations on its use, it is helpful to understand the mechanism by which U.S. SEZs reduce intermediate tariffs. U.S. SEZs are outside the customs boundaries, and so goods that enter zones from abroad never cross customs boundaries and do not face tariffs.[11] In order for outputs to be consumed domestically they must cross customs boundaries,

[11] Only approved intermediates may do this: other intermediates are required to first clear U.S. customs before entering the zone.

and tariffs are assessed when they do so. Critically, the tariff rates may (but need not) be based on the final good, since that is what is crossing the customs boundaries. Thus, petrochemicals produced in a U.S. SEZ will face the tariff on petrochemicals when they are brought across U.S. customs boundaries for domestic consumption. However, the tariff will only be applied to the share of the petrochemicals representing foreign inputs; the share representing value added in the U.S. SEZ (labor, capital, profits, domestically produced inputs) is not treated as imported and will not face a tariff. Since the tariff on petrochemicals is generally zero, this is advantageous to the firm in the SEZ compared to paying tariffs on the foreign inputs used produced them (e.g. the tariff on crude oil which is either $0.052 / barrel or $0.105 / barrel).

The caveat to the above is that a firm in a zone may have a choice over which tariffs is pays. In particular, it may enter goods in "unprivileged foreign status", in which case the process outlined above applies and it will obtain the inverted tariff. If it enters the good in "privileged foreign" status, then it will be taxed as if it were still in intermediate form when the final goods crosses U.S. customs boundaries. In this case there are duty deferrals when goods are sold domestically and duty reductions when the goods are exported, but the inverted tariff does not apply if the good is sold domestically. A firm might choose to do this if it is required by the Board or if the tariff applicable to the final good is higher than the tariff applicable to the intermediate. Finally, goods that enter U.S. SEZs in "domestic status" are either sourced domestically or have all duty paid prior to entering a SEZ, and are not eligible for tariff reductions or deferrals.

Appendix 3.2: History of U.S. SEZs

SEZs were first established by legislation in 1934, in response to the Smoot-Hawley tariffs, which seriously damaged U.S. firms engaged in re-export. These firms lobbied for and obtained special areas to be treated as outside the customs borders, so that merchandise could stop in these areas in transit without incurring tariffs. Manufacturing was not permitted. Early SEZs were located near major ports, like New York (established in 1936), Mobile (1937), New Orleans (1946), and San Francisco (1948). The program was very small during this period.

In 1950, Congress passed legislation permitting manufacturing activity in SEZs. While early SEZs were adjacent to ports, since 1954 U.S. SEZs have had two types of areas: "general purpose" zones and subzones. General purpose zones are at least loosely attached to a port of entry (e.g., seaport or airport), but have flexible boundaries that can be adjusted to include or exclude a company that wishes to enter or leave a zone, and may have non-contiguous parts. Subzones are even more flexible: although they are nominally affiliated with a general purpose zone, they can be located nearly anywhere. The stated purpose of subzones is to accommodate firms that cannot operate in a general purpose zone. In practice, almost all manufacturing activity in U.S. SEZs takes place within subzones, while most distribution and wholesaling activity takes place within general purpose zones.

In 1980, there was an administrative change to the program, which freed manufacturers from paying duty on domestic value added in manufacturing. In 1982 a second ruling also exempted zone manufacturers from duty on transportation and brokerage costs.[12] To understand the impact of these changes, it helps to be familiar with the discussion of inverted tariff rules from the prior subsection of this appendix. Before 1980, the tariff applicable to the final good was applied to the entire value of the final good when it entered U.S. customs territory from a U.S. SEZ. After the 1980 and 1982 rule changes, only the share of foreign value added was dutiable, effectively establishing

[12] These rule changes were prompted directly by lobbying from interested industries. Miller & Company, P.C., a law firm frequently listed on SEZ applications claims that "Mr. Miller [the firm principal] drafted and secured the amendment to Section 146.48(e) of U.S. Customs and Border Protection ... Foreign-Trade Zone Regulations".

inverted tariff rules for goods sold domestically. The 1980 rule change, combined with increasingly international supply chains, led to widespread manufacturing activity in SEZs.

Finally, there was an important rule change in 1991 which standardized rules and gave intermediate producers greater weight in the approval process.

Appendix 3.3: Comparison of U.S. SEZs to those in other rich countries

The U.S. SEZ program has many similarities to programs in other rich countries. An explicit comparison is made in the May, 2004 FTZ Staff Report: "Enhancing the Foreign-Trade Zones Program for Small and Medium-Sized Manufacturers". The most similar program in the E.U is called "Processing under customs control"; it is not place-based and uses inverted tariff rules. (Also see Cernat and Pajot (2012) for more information about the E.U. program.) In Australia, the comparable program is called "Manufacturing in Bond" which is not place-based, but only reduces tariffs on intermediates in production for export. In Japan, the comparable program is the "Foreign Access Zone" which is not place-based, and includes other loan and tax incentives. The zones permit processing outside of customs, but the tariff treatment of foreign intermediates is opaque.

Appendix 4: Empirical work and stylized facts

In this appendix, I provide additional information about the data and methods used in the empirical section of the main text. I also examine the robustness of my baseline cross-sectional and time-series results.

Appendix 4.1: Inverted tariffs and GATT/WTO rules

In the main text, I argue that the assignment of all lower-tier users to the inverted tariff is necessary to comply with GATT/WTO rules, and in particular the Agreement on Subsidies and Countervailing Measures (SCMA). In this section, I discuss the legal scholarship supporting this conclusion.

It is generally agreed by legal scholars that developing-country SEZs, which tend to grant zero tariffs to all firms, are in violation of the SCMA, which prohibits export subsidies, including selective tariff exemptions (see, e.g., de Almeida (2014); Creskoff and Walkenhorst (2009); Engman, Onodera, and Pinali (2007); Granados (2002); Laird (1997); Torres (2007); and Waters (2013)). The only exceptions are for the lowest income countries, which are exempt from the SCMA, while other countries have received a series of temporary exemptions. The remaining countries appear to be in violation of WTO rules but for uncertain reasons have not faced WTO disputes.[13]

In contrast, the inverted tariff reductions given to U.S. firms appear to be consistent with the SCMA. As part of the SCMA, countries are required to regularly declare their subsidy programs; however, the U.S. declarations do not mention the inverted tariff as a subsidy.[14] Furthermore, it is clear the WTO is aware of U.S. SEZs more broadly and the inverted tariff rules in particular, as the program is discussed in (at least) the last three trade policy reports for the U.S. (S307, S275, S200, the latter two of which explicitly discuss the inverted tariff rules. Legal scholarship suggests that no other type of tariff reduction is consistent with WTO rules. Torres (2007) argues that developing countries must either abandon tariff reductions for imported goods (and remove export

[13]It is suggested in de Almeida (2014) that countries have a tacit agreement not to challenge each others' SEZ programs, although a carve-out could easily be put in the SCMA as has been done for duty drawbacks.

[14]See, e.g., WTO reports N305 and N284 for the USA. In fact, both reports discuss the U.S. SEZ program ("Foreign-Trade Zones"), but only for subsidies arising from sub-federal programs – some states give state and local tax reductions to all firms in SEZs in their state. These are considered subsidies by the WTO, but are not granted by the Federal Government, are not granted to SEZs in most states, and are not related to the inverted tariff rules.

requirements) or adopt a U.S.-style system with an inverted tariff for imported goods. Thus, while the government may wish to charge lower tariffs on lower-tier firms, the inverted tariff is the best they are able to achieve without violating WTO/GATT rules.

Appendix 4.2: Derivation of political weights:

In this section, I describe how I calculate the political weights for output industries used in the cross-sectional regressions in the main text.

I work from a setting closely related to Grossman and Helpman (1995b), and make identical assumptions about the economic environment but use reduced-form political weights (rather than otaining weights as the consequence of a bargaining paper). Consequently, the government has the objective function

$$\Omega = L + \sum_{g} \left(\lambda_g \pi_g + CS_g + Rev_g \right)$$

where λ_g is a reduced-form weight on π_g, the profits in industry g, CS_g is the consumer surplus from consuming good g, and Rev_g is tariff revenue from industry g. This yields a FOC with respect to t_g,the ad-valorem wedge between domestic and world prices of good g:

$$0 = \lambda_g y_g - x_g + \left(1 - \frac{\partial p_g^w}{\partial p_g}\right) M_g + t_g p_g^w \frac{\partial M_g}{\partial p_g}$$

which can be manipulated to yield

$$\lambda_g = 1 + e_{p_g}^{M_g} \frac{M_g}{y_g} \left(\frac{1}{1+t_g} \left(t_g - \frac{1}{e_{p_g^w}^{E_g^w}} \right) \right)$$

where all of the relevant variables are at their equilibrium values under Column 2 tariffs.

I assume that the elasticities of import demand ($e_{p_g}^{M_g}$) and foreign export supply ($e_{p_g^w}^{E_g^w}$) are constant, so that I can use values estimated at current applied tariff rates. However, I must calculate the import volumes and production values that would arise under Column 2 tariffs. To do this, I first estimate the change in domestic prices that would be caused by a shift from current applied tariffs to Column 2 tariffs, and then calculate how this change in prices would affect domestic output and import volumes.

To calculate domestic prices, I use the identity $p_g = (1 + t_g) p_g^w$ and world market clearing $E^w \left(p_g^w\right) = M_g \left(p_g\right)$. Differentiating both equations with respect to t_g yields

$$\frac{\partial p_g}{\partial t_g} = p_g^w + (1 + t_g) \frac{\partial p_g^w}{\partial t_g}$$
$$\frac{\partial p_g^w}{\partial t_g} = \frac{1}{1+t_g} \frac{e_{p_g}^{M_g}}{e_{p_g^w}^{E_g^w}} \frac{\partial p_g}{\partial t_g}$$

so that combining these equations I obtain a differential equation for the domestic price as a function of the tariff

$$\frac{\partial p_g}{\partial t_g} = \frac{1}{1+t_g} \cdot \frac{e_{p_g^w}^{E_g^w}}{e_{p_g^w}^{E_g^w} + e_{p_g}^{M_g}} p_g$$

which I use in the next step.

Second, I assume destination-specific capital as in Ludema and Mayda (2013) and Ludema, Mayda, Yu, and Yu (2018) and shared production functions in all locations, so that the elasticity of foreign export supply is equal to the elasticity of domestic output. Then, using the assumption that output and import demand elasticities are constant, I can set up and solve differential equations determining imports and domestic output as a function of tariffs (where I substitute in the differential equation for domestic price as a function of tariffs) to obtain:

$$\begin{aligned}\frac{\partial M_g}{\partial t_g} &= \frac{\partial M_g}{\partial p_g}\frac{\partial p_g}{\partial t_g} \\ &= -\frac{M_g}{1+t_g}\cdot\frac{e_{p_g^w}^{E_g^w}\, e_{p_g}^{M_g}}{e_{p_g^w}^{E_g^w}+e_{p_g}^{M_g}}\end{aligned}$$

$$M_g\left(t_g^{col2}\right) = M_g\left(t_g^{app}\right)\left(\frac{1+t_g^{app}}{1+t_g^{col2}}\right)^{\frac{e_{p_g^w}^{E_g^w}\, e_{p_g}^{M_g}}{e_{p_g^w}^{E_g^w}+e_{p_g}^{M_g}}}$$

and

$$\begin{aligned}\frac{\partial y_g}{\partial t_g} &= \frac{\partial y_g}{\partial p_g}\frac{\partial p_g}{\partial t_g} \\ &= \frac{y_g}{1+t_g}\cdot\frac{\left(e_{p_g^w}^{E_g^w}\right)^2}{e_{p_g^w}^{E_g^w}+e_{p_g}^{M_g}}\end{aligned}$$

$$y_g\left(t_g^{col2}\right) = y_g\left(t_g^{app}\right)\left(\frac{1+t_g^{col2}}{1+t_g^{app}}\right)^{\frac{\left(e_{p_g^w}^{E_g^w}\right)^2}{e_{p_g^w}^{E_g^w}+e_{p_g}^{M_g}}}$$

These equations can then be calculated with readily available data.

Appendix 4.3: Derivation of average elasticity of import demand:

In this section, I describe how I estimate the elasticities of import demand used in the cross-sectional regressions in the main text.

I show the derivation of the average elasticity of import demand by final good industry h for intermediate g. The jumping off point is a production functionsimilar to Goldberg et al. (2010), with Cobb-Douglas demand across intermediates, labor, and sector specific capital.[15]

$$y_g = A_g\prod_{h=1}^{H} x_{gh}^{\alpha_{gh}} L_g^{\alpha_{gL}} K_g^{\alpha_{gK}} \text{ s.t. } \sum_h \alpha_{gh} + \alpha_{gL} + \alpha_{gK} = 1$$

Next, I assume that domestically produced and foreign produced goods within a given variety are perfect substitutes. This formulation is consistent with my model, and the overall production function is consistent with the generalization to non-separable production functions in Appendix 4. Thus,

$$x_{gh} = x_{gh}^{home} + x_{gh}^{foreign}$$

[15] This is not consistent with the production function used in the main text, but is consistent with the extension earlier in this appendix in which production functions are not additively separable across variable inputs.

Again following Goldberg et al. (2010), I assume CES demand across different foreign source countries (denoted v)within each intermediate h, such that

$$x_{gh}^{foreign} = \left(\sum_{v \in V_h} \left(b_h^v\right)^{\frac{1}{\sigma_h}} \left(x_{gh}^v\right)^{\frac{\sigma_h - 1}{\sigma_h}} \right)^{\frac{\sigma_h}{\sigma_h - 1}}$$

Although the Cobb-Douglas factor shares are allowed to vary freely by final good industry, the elasticity of substitution across source countries within each intermediate is assumed to be the same for all using industries as well as consumers.

This formulation is driven by data limitations, much as in Goldberg et al. (2010) and Feenstra (1994). A Cobb-Douglas upper tier is necessary as there is no time series for the most detailed U.S. I-O table. Furthermore, it is not possible to uses consumption shares at the HS6 level – while import consumption is observed at that level, domestic consumption is not. The assumption of CES demands across source countries is made for consistency with the data; however, since tariff reductions do not vary by source country,[16] this tier of demand is not relevant for the elasticities I calculate.

An outside good produced only with labor pins down wages to 1, consistent with the theoretical model in the main text. Therefore optimized production implies that

$$y_g = \left[A_g K_g^{\alpha_{gK}} \left(\alpha_{gL} p_g\right)^{\alpha_{gL}} \prod_{h \in H_g} \left(\alpha_{gh} \frac{p_g}{p_{gh}} \right)^{\alpha_{gh}} \right]^{\frac{1}{\alpha_{gK}}}$$
$$x_{gh} = \alpha_{gh} \frac{p_g y_g}{p_{gh}}$$

which in turn implies that

$$\frac{\partial x_{gh}}{\partial p_{gh}} = -\left(1 + \frac{\alpha_{gh}}{\alpha_{gK}}\right) \frac{x_{gh}}{p_{gh}}$$
$$e_{p_{gh}}^{x_{gh}} = 1 + \frac{\alpha_{gh}}{\alpha_{gK}}$$

In the data, an intermediate industry is an industry from the detailed BEA 2007 I-O table. I take I-O shares from this table, and define varieties within an industry as the set of HS 6-digit codes that at least partly map to that industry. However, the data on tariff reductions are at the level of HS 6-digit codes, so what I derive is the average elasticity of intermediate use across HS 6-digit codes within a given I-O industry. Thus, I compute the average elasticity across HS 6-digit codes within an industry as

$$\left|\left| e_{p_{gh}}^{x_{gh}} \right|\right| = 1 + \frac{\alpha_{g\eta}}{||V_h|| \alpha_{gK}}$$

where $||V_h||$ is the number of HS 6-digit codes within an I-O table code η, and $\alpha_{g\eta}$ is the expenditure share on intermediates from that I-O table code.

Appendix 4.4: Alternate cross-sectional specifications:

In this section, I consider a number of alternate specifications for the cross-sectional regression presented in Table 1 of the main text. In the first set of regressions (Tables 1 and 2 of this appendix),

[16] There is generally a distinction between countries facing Column 1 and Column 2 tariffs, but effectively all U.S. imports enter under Column 1 tariffs.

I show that alternative methods of estimating political weights give similar results. In the second (Table 3), I show that my empirical results are stronger under a less conservative definition of a SEZ. Results are also stronger if a logit or probit model is used instead of a linear probability model (Table 4). In Tables 5 through 8, I show that the results are robust to a number of different restrictions, including placing less weight on the parametric value of elasticity estimates, disaggregating SEZs by year, restricting observations to the set with positive use in the I-O table, and excluding oil refining.

Note that throughout this section, I report only clustered standard errors, as these are more conservative, to save space.

In the main text, I restrict the cross-sectional regression to observations for which the baseline weights are well estimated: those for which the weight estimate is at least 1. This is a natural point to trim the weights, as the theory in this paper conditions on weights which are greater than one (and concords with intuition that most industries in the U.S. are organized and have a larger weight in the government objective than their their weight in the social welfare function). Values less than one arise when the estimate of the inverse elasticity of foreign export supply is higher than the U.S. column 2 tariff. This may reflect errors in the estimation of foreign export supply elasticities. However, Table 1 shows that trimming the sample in this way is not driving the results. In the first two columns I present results without any trimming or adjustment of the estimated political weights. The results are slightly weaker (although all of these specifications use clustered standard errors, which as discussed in the text, are too conservative). In columns 3 and 4, I winsorize rather than trim; this yields similar results as in the unadjusted case, but with slightly stronger results for political weights and slightly weaker ones for output tariffs.

A second objection to the weights used in the main text might be that they are based on a production function that does not include intermediate goods. In Table 2, I therefore repeat the estimation using weights calculated in a framework that does include intermediates. The drawback of this approach is that it requires assuming that the elasticity of domestic input demand is equal to the elasticity of foreign export supply, because using the most detailed I-O table does not offer time variation to estimate these parameters separately. For similar reasons, production elasticities are taken from Cobb-Douglas shares in the I-O table.[17] Estimates calculated using these alternative weights are consistent with the baseline specification, and are presented in Table 2. In column 1, I show estimates when these weights are trimmed to be greater than 0.[18] In column 2, I do not trim the weights, while in column 3 I winsorize at 0. Results are somewhat weaker than under the baseline for tariffs (and in general the standard errors on all coefficients are larger, although again, all of these are corrected for clustering and so are conservative) but overall the coefficients are consistent.

In Appendix Table 3, I present results for main text Table 1 when I use a different definition of SEZs. In the specifications in the main text, I code an input-output pair as having an SEZ if there is any primary SEZ permitted for that input-output pair. This includes combinations that cannot be used to lower tariffs on intermediates when the final good is sold domestically (i.e. intermediates that must enter in privileged foreign status) but excludes combinations that only permit limited activity (secondary permissions) and permissions on inputs that do not face tariffs during the period of interest.[19] In this table, I present specifications using both looser and more stringent definitions

[17]Both of these problems can be corrected using coarser I-O tables, for which a time series is available.

[18]This is a different level than that used for the baseline weights. The reason is that these weights are generally between 0 and 1 and trimming at 1 would remove most of the sample. Weights between 0 and 1 are theoretically possible although not fully consistent with the model used in this paper; weights less than 0 would be hard to justify theoretically

[19]E.g. if an input-output pair was granted in the 1980s when the input faced tariffs but the tariff is zero in 2011, this pair is excluded.

Table 1: Cross-sectional results: different treatment of low weights

	(1) Has an SEZ	(2) Has an SEZ	(3) Has an SEZ	(4) Has an SEZ	(5) Has an SEZ	(6) Has an SEZ
Unadjusted weight	0.0880	0.0881	0.0856			
	(0.0286)	(0.0286)	(0.0314)			
Winsorized weight				0.129	0.129	0.109
				(0.0257)	(0.0257)	(0.0240)
Output tariff	-0.0311	-0.0311	-0.0367	-0.0284	-0.0285	-0.0352
	(0.0258)	(0.0258)	(0.0246)	(0.0263)	(0.0263)	(0.0250)
Use elasticity	0.0141	0.0131	0.0160	0.0158	0.0148	0.0168
	(0.00636)	(0.00578)	(0.00607)	(0.00698)	(0.00640)	(0.00628)
Observations	66,822	66,822	66,822	66,822	66,822	66,822
Input FEs	yes	yes	yes	yes	yes	yes
IO use control		yes	yes		yes	yes
Unskilled intensity			yes			yes
Output TOT			yes			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

Table 2: Cross-sectional results: alternative output weights

	(1)	(2)	(3)	(4)	(5)	(6)
	Has an SEZ	Has an SEZ	Has an SEZ	Has an SEZ	Has an SEZ	Has an SEZ
Trimmed alternate weight	0.141	0.122				
	(0.0316)	(0.0355)				
Unadjusted alternate weight			0.129	0.108		
			(0.0471)	(0.0384)		
Winsorized alternate weight					0.202	0.176
					(0.0256)	(0.0284)
Output tariff	-0.0262	-0.0309	-0.0248	-0.0318	-0.0264	-0.0315
	(0.0274)	(0.0269)	(0.0253)	(0.0245)	(0.0262)	(0.0257)
Use elasticity	0.0138	0.0139	0.0156	0.0165	0.0148	0.0148
	(0.00691)	(0.00644)	(0.00739)	(0.00666)	(0.00709)	(0.00636)
Observations	62,160	62,160	66,822	66,822	66,822	66,822
Input FEs	yes	yes	yes	yes	yes	yes
IO use control		yes		yes		yes
Unskilled intensity		yes		yes		yes
Output TOT		yes		yes		yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

of a SEZ. In columns 1 and 2,an input-output pair is coded as having a SEZ only if there is a primary approval and it can be used to lower tariffs on at least some tariff lines if the outputs are sold domestically; this is a more restrictive definition than used in the specifications in the main text. In columns 3 and 4, the definition of SEZ is expanded to include combinations that only permit limited activity (secondary permissions).

Again, the results are largely consistent with those in the main text. The main difference is in the coefficient on output tariffs. In columns 1 and 2, this coefficient is similar in magnitude to the main specification but is more precisely estimated. This makes sense, as the output tariff should only matter for SEZs with inverted tariff benefits. Thus, this definition is probably most consistent with the theory and the more precise estimations can be taken as additional supporting evidence. On the other hand, in columns 3 and 4 the coefficient on output tariffs is both smaller and more less precisely estimated. This probably reflects attentuation arising from the addition of secondary permissions, which only permit limited activity and so may not reflect the same considerations as primary permissions. However, the results are nevertheless largely consistent with the baseline results.

Table 3: Cross-sectional results: Different SEZ definitions

	(1)	(2)	(3)	(4)	(5)	(6)
	Has an SEZ with inverted tariffs	Has an SEZ with inverted tariffs	Has an SEZ with inverted tariffs	Has an SEZ more broadly defined	Has an SEZ more broadly defined	Has an SEZ more broadly defned
Political weight	0.124	0.124	0.0856	0.107	0.107	0.0628
	(0.0314)	(0.0314)	(0.0286)	(0.0252)	(0.0251)	(0.0210)
Output tariff	-0.0814	-0.0817	-0.0847	-0.0384	-0.0386	-0.0384
	(0.0279)	(0.0280)	(0.0257)	(0.0288)	(0.0288)	(0.0263)
Use elasticity	0.0197	0.0121	0.0138	0.0153	0.0104	0.0132
	(0.00585)	(0.00616)	(0.00679)	(0.00565)	(0.00612)	(0.00660)
Observations	41,440	41,440	41,440	41,440	41,440	41,440
Input FEs	yes	yes	yes	yes	yes	yes
IO use control		yes	yes		yes	yes
Unskilled intensity			yes			yes
Output TOT			yes			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

In Appendix Table 4, I present results for main text Table 1 using logit and probit specifications. The results are similar in sign and significance to the linear specifications presented in the main text.

Table 4: Cross-sectional results: Different functional forms

	(1) Logit Has an SEZ	(2) Logit Has an SEZ	(3) Logit Has an SEZ	(4) Probit Has an SEZ	(5) Probit Has an SEZ	(6) Probit Has an SEZ
Political weight	0.532	0.532	0.375	0.293	0.293	0.208
	(0.144)	(0.144)	(0.133)	(0.0777)	(0.0777)	(0.0717)
Output tariff	-0.306	-0.308	-0.330	-0.167	-0.168	-0.177
	(0.124)	(0.124)	(0.123)	(0.0639)	(0.0641)	(0.0620)
Use elasticity	0.141	0.0503	0.066	0.0499	0.0219	0.0280
	(0.108)	(0.0410)	(0.0553)	(0.0314)	(0.0157)	(0.0171)
Observations	32,640	32,640	32,640	32,640	32,640	32,640
Dep. var. mean	0.389	0.389	0.389	0.389	0.389	0.389
Dep. var. SD	0.487	0.487	0.487	0.487	0.487	0.487
Input FEs	yes	yes	yes	yes	yes	yes
IO use control		yes	yes		yes	yes
Unskilled intensity			yes			yes
Output TOT			yes			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output

All right-hand side variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

In Appendix Table 5, I present the results for main text Table 1, in which I place less weight on the exact estimation of elasticities, and instead classify elasticities into above or below median elasticity. These results are similar to the main specification, suggesting that the exact method of calculating elasticities is not driving the results.

In Appendix Table 6, I present the results for main text Table 1, but considering only the input-output combinations that are active in a single year (in the main specification I pool across 2011-2015). These results are very similar to those in the main specification (and in fact the coefficients are, if anything, generally slightly larger and more precisely estimated). This suggests that the aggregation across years is not driving the results.

Table 5: Cross-sectional results: elasticity dummies

	(1) Has an SEZ	(2) Has an SEZ	(3) Has an SEZ
Political weight	0.121	0.122	0.0844
	(0.0306)	(0.0306)	(0.0280)
Output tariff	-0.0800	-0.0802	-0.0833
	(0.0275)	(0.0276)	(0.0253)
$>$ Median use elasticity	0.121	0.118	0.108
	(0.0129)	(0.0128)	(0.0118)
Observations	41,440	41,440	41,440
Input FEs	yes	yes	yes
IO use control		yes	yes
Unskilled intensity			yes
Output TOT			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

Table 6: Cross-sectional results: Not pooled across years

	(1) Has an SEZ 2011	(2) Has an SEZ 2012	(3) Has an SEZ 2013	(4) Has an SEZ 2014	(5) Has an SEZ 2015
Political weight	0.133	0.139	0.117	0.130	0.134
	(0.0458)	(0.0464)	(0.0439)	(0.0316)	(0.0326)
Output tariff	-0.0906	-0.0853	-0.0873	-0.0702	-0.0772
	(0.0257)	(0.0249)	(0.0242)	(0.0265)	(0.0276)
Use elasticity	0.0129	0.0138	0.0200	0.0205	0.0202
	(0.00927)	(0.00919)	(0.00611)	(0.00601)	(0.00595)
Observations	41,440	41,440	41,440	41,440	41,440
Input FEs	yes	yes	yes	yes	yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

In Appendix Table 7, I present results that restrict the sample to input-output combinations that have positive intermediate use in the input-output table. Again, the results are generally consistent with those in the main text, although the coefficients on elasticity are smaller than in the baseline specification, and some of these coefficients are not statistically different from 0 at the 10% level (however, as previously discussed the clustered standard errors in this specification are

Table 7: Cross-sectional results with positive use

	(1)	(2)	(3)
	Has an SEZ	Has an SEZ	Has an SEZ
Political weight	0.156	0.156	0.115
	(0.0370)	(0.0370)	(0.0354)
Output tariff	-0.0958	-0.0958	-0.100
	(0.0377)	(0.0377)	(0.0349)
Use elasticity	0.0200	0.0200	0.0285
	(0.0134)	(0.0134)	(0.0153)
Observations	8,229	8,229	8,229
Input FEs	yes	yes	yes
Unskilled intensity			yes
Output TOT			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. “Has an SEZ” is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. “Use elasticity” is the elasticity of intermediate use, “Output tariff” is the output ad-valorem equivalent tariff, “Political weight” is the output industry political weight, “Unskilled intensity” is the unskilled labor intensity of the output industry, and “Output TOT” is a control for output industry terms-of-trade power.

too conservative)

In Appendix Table 8, I present the results for main text Table 1, in which I show that the results are not driven by the oil refining industry. In this specification, I drop input-output pairs with an oil refining output industry (in particular, the codes in the IO table corresponding to “Petrochemical manufacturing” – 325110 and “Petroleum and coal products” – 324110; 324121; 324122; and 324190) and show that the results are the same as those in the main specification.

Appendix 4.5: Alternate time-series specifications:

In Appendix Table 9, I present time-series results for main text Table 3 when I use a different definition of SEZs. In the main text, I define a new SEZ approval as any primary approval using a given input. In this table, I use a looser definition, and include both primary and secondary approvals. The results are consistent with the main results.

Table 8: Cross-sectional results: excluding the oil industry

	(1)	(2)	(3)
	Has an SEZ	Has an SEZ	Has an SEZ
Political weight	0.124	0.124	0.0852
	(0.0313)	(0.0313)	(0.0284)
Output tariff	-0.0817	-0.0820	-0.0850
	(0.0280)	(0.0280)	(0.0258)
Use elasticity	0.0199	0.0124	0.0141
	(0.00587)	(0.00626)	(0.00693)
Observations	41,440	41,440	41,440
Input FEs	yes	yes	yes
IO use control		yes	yes
Unskilled intensity			yes
Output TOT			yes
Standard errors	Clustered: Output	Clustered: Output	Clustered: Output

All variables are standardized over the subsample for each regression. "Has an SEZ" is an indicator equal to one if a firm active in any year between 2011-2015 is permitted to use the input-output pair in an SEZ, and zero otherwise. "Use elasticity" is the elasticity of intermediate use, "Output tariff" is the output ad-valorem equivalent tariff, "Political weight" is the output industry political weight, "Unskilled intensity" is the unskilled labor intensity of the output industry, and "Output TOT" is a control for output industry terms-of-trade power.

Table 9: Changes in import volumes: Different SEZ definition

	OLS	OLS	2SLS
	New approvals	New approvals	New approvals
1-year lagged import change	0.0112	0.00168	1.220
	(0.00318)	(0.00157)	(0.463)
Observations	34,859	34,858	34,858
Dep. var. mean	0.563	0.563	0.563
Dep. var. SD	1.308	1.308	1.308
Year FEs		yes	yes
HS6 FEs		yes	yes
1st Stage F-stat.			112.0
Clustering	HS6	HS6	HS6

Note: All point estimates are in units of new approvals per million dollar change in imports

In Appendix Table 10, I present time-series results for main text Table 2 when I include final as well as intermediate goods. In the main text, I restrict attention to goods classified as intermediates by the "Broad Economic Categories" (BEC) classification. The inclusion of non-BEC goods weakens the results (as would be expected if the BEC classification is correct), and the point estimate on the uninstrumented regression with fixed effects is weakly negative (and close to zero). However, the instrumented regression is still significant and in the direction predicted by the theory.

Table 10: Changes in import volumes: Including final goods

	OLS New approvals	OLS New approvals	2SLS New approvals
1-year lagged import change	0.0102	-0.00174	0.681
	(0.00197)	(0.00493)	(0.163)
Observations	56,489	56,488	56,488
Dep. var. mean	0.253	0.253	0.253
Dep. var. SD	0.826	0.826	0.826
Year FEs		yes	yes
HS6 FEs		yes	yes
1st Stage F-stat.			305.3
Clustering	HS6	HS6	HS6

Note: All point estimates are in units of new approvals per million dollar change in imports

In Appendix Table 11, I present time-series results for main text Table 2 when I exclude imports of petroleum (1996 HS6 code 2709.00). The instrumented regression is robust to this change. In the regression without fixed effects, this leads to a statistically insignificant result, but it is actually larger in magnitude than the regression including petroleum, it is simply less precise. The regression with fixed effects gives a negative point estimate but is is very weak.

Table 11: Changes in import volumes: Excluding petroleum

	OLS New approvals	OLS New approvals	2SLS New approvals
1-year lagged import change	0.0711	-0.0233	1.460
	(0.0529)	(0.0338)	(0.656)
Observations	34,843	34,842	34,842
Dep. var. mean	0.304	0.304	0.304
Dep. var. SD	0.891	0.891	0.891
Year FEs		yes	yes
HS6 FEs		yes	yes
1st Stage F-stat.			2290
Clustering	HS6	HS6	HS6

Note: All point estimates are in units of new approvals per million dollar change in imports

In Appendix Table 12, I present time-series results for main text Table 2 when I use a longer time difference to better identify permanent changes. In this specification I use a 2-year time difference. (This effectively cuts the sample in half, which is why I do not run longer time differences.) In this specification, I regress new approvals over a two year period on the change in trade flows over that period. The point estimates are generally larger than in the shorter time period but there is still a substantial difference from the instrumented regression.

Table 12: Changes in import volumes: Longer time differences

	OLS 2-year new approvals	OLS 2-year new approvals
2-year import change	0.0173	0.0102
	(0.00469)	(0.00274)
Observations	17,776	17,746
Dep. var. mean	0.308	0.308
Dep. var. SD	0.796	0.796
Year FEs		yes
HS6 FEs		yes
Clustering	HS6	HS6

Note: All point estimates are in units of new approvals per million dollar change in imports

Appendix 5: Data and derivations

In this section, I provide additional statistics about U.S. SEZs and details about how the datasets used in the paper and the facts and figurescited in the text were constructed. In Appendix 5.1, I provide additional details about which outputs are produced within U.S. SEZs using tariff-reduced intermediates. In Appendix 5.2, I explain in detail the process used to construct the set of permissions and concord those permissions to the 2007 BEA input-output table. In Appendices 5.2 and 5.3, I explain how I identified the locations of SEZs within the U.S. and how I concorded other data used in the cross-sectional regression to the input-output table. In the paper, I present a number of facts and figures about the U.S. SEZ program; I explain the derivation of these numbers in Appendix 5.5.

Appendix 5.1: U.S. SEZ output by industry

In Appendix Table 13, I report gross output in U.S. SEZs by 3-digit 2007 NAICS code.

Appendix 5.2: Constructing the Set of Approvals:

The FTZ Board's Annual Report to Congress lists active manufacturers during the prior year and the value of their intermediate use.[20][21] I used these reports to compile a list of all manufacturers who were ever active in any SEZ from 2000 to 2015. I then identified all "Board orders" relating to each manufacturer, including approvals and other decisions, which are reported by the FTZ Board. For manufacturers active 2011-2015, this includes approvals made in any year. For firms active from 2000-2010 (but not 2011-2015), I only collect approvals after 2000. In order to manufacture in a zone, a firm must have at least one such approval; however, many firms have multiple approvals, with subsequent approvals expanding authority to some combination of new outputs, components, and scale. As a result, I have collected two (overlapping) datasets: (1) the universe of approvals

[20]This does not necessarily include all manufacturers with active approvals, as firms may have an approval but not use it if the plant is idle or manufacturing goods not on the approved scope.

[21]For years 2010 and earlier, the Annual Report does not list active manufacturers; instead, it divides activity between general purpose zones and subzones. During this time period, I identify active manufacturers by looking for manufacturing orders associated with zones which have any reported activity during the relevant time period. As a result, active manufacturers are less precisely identified than in the period after 2011.

Table 13: U.S. SEZ output by industry

Industry name	U.S. SEZ output ($ million)
Petroleum and Coal Products Manufacturing	360,000
Chemical Manufacturing	300,000
Transportation Equipment Manufacturing	82,000
Oil and Gas Extraction	76,000
Machinery Manufacturing	53,000
Mining (except Oil and Gas)	27,000
Computer and Electronic Product Manufacturing	26,000
Electrical Equipment, Appliance, and Component Manufacturing	13,000
Primary Metal Manufacturing	3,100
Food Manufacturing	3,000
Miscellaneous Manufacturing	1,800
Fabricated Metal Product Manufacturing	1,500
Nonmetallic Mineral Product Manufacturing	500
Plastics and Rubber Products Manufacturing	480
Furniture and Related Product Manufacturing	390
Beverage and Tobacco Product Manufacturing	230
Paper Manufacturing	210
Leather and Allied Product Manufacturing	83
Publishing Industries (except Internet)	63
Motion Picture and Sound Recording Industries	42
Apparel Manufacturing	32
Textile Mills	29
Textile Product Mills	19
Printing and Related Support Activities	14
Wood Product Manufacturing	2.8

Note: Imputed from author-collected data and BEA input-output tables.

that permit manufacturing from 2011-2015, and (2) the universe of (ever active) approvals from 2000-2015.

The content of approvals are not reported by the Board, although they are a matter of public record, and so I compiled this information from a variety of sources. In order to manufacture in a zone, firms must submit a list of proposed products and components to the Board, which are then announced in the Federal Register (a newspaper published by the U.S. government). After the FTZ Board rules on the application, a subsequent announcement is made declaring whether the application has been rejected, partly accepted (along with which products and components have not been accepted), or fully accepted.

In order to collect the HTS codes for approved products and components, when possible I consulted the original application files. Applications from 2009 onward are provided electronically through the FTZ website, while lists of approved products and components from selected approved applications from 1998 - present are included in the online "T/IM Database". For most of the remaining applications, I was able to access the original documents at the U.S. Department of Commerce in Washington, D.C.[22]

In less than 10% of cases (27 of 461 applications) for which applications were either not public or had been lost, I turned to product lists in the Federal Register. Unlike the original application files, most Federal Register announcements include product descriptions but not codes. In these cases, I hand-coded the products based on the Federal Register descriptions. This permitted me to capture the inputs and outputs for a further 29 applications.

After an application has been approved (or rejected), an additional announcement is made in the Federal Register giving the date of approval and any restrictions (e.g. if certain inputs are not approved for tariff reductions or are only approved for more limited reductions).[23] Additionally, applicants may commit to restrictions in either the original application or they may amend the application during the application process. These may be noted in the final Federal Register announcement, and so I collected information about restrictions on either a an entire code or part of a code both from the original applications and also from the time of final approval.

There are seven missing approvals for which I could not determine the approved inputs and outputs. These approvals fall into three different groups. First, very early in the program, Federal Register notices did not include lists of products and components, so for three applications that were missing or uninformative during this time, I was unable to fill in using the Federal Register. Second, manufacturing activity in general purpose zones during the 1980s did not require the same type of approval, and did not create the type of public information which is the basis of my dataset (no public application, no announcement in the Federal Register, etc.); this causes an additional two missing applications. And third, staff cases (which are reserved for certain very restricted types of approvals) never lead to public applications and announcements in the Federal Register. There are two staff cases in my dataset and I cannot identify products or components for these applications.

Although most applications provide HS6 codes, some list products and components at other levels of specificity instead (usually HS4, sometimes HTSUS8). I interpret codes at the HS4 as encompassing all HS6 within those HS4. In the case of HS8 approvals, I treat these as an approval

[22] In three cases, firms were permitted to exclude products and components from public files and instead submit them to the FTZ board in confidential documents which I cannot access. Also, in a few cases application files have been lost, and applications from very early in the program (before the mid-1980s) contain significantly less detail than more recent applications.

[23] Goods can be restricted to domestic status, which prohibits any duty reductions or deferrals, or privileged foreign status, which permits duty deferrals and eliminated tariffs when the output is exported but does not change tariffs when the output is sold domestically (i.e. firms may not use inverted tariffs on inputs in this group). These restrictions may not apply to an entire HS6, and may be applied to subcodes or to inputs from specified countries, e.g. those subject to anti-dumping or counter-vailing duties.

at the relevant HS6 level, but with a partial restriction if the HS6 contains multiple HS8 codes.

Changes to the classifications of traded products across time also pose a challenge. These changes are characterized by a number of many-to-many matches. I concord all codes for approvals from 2000 - 2015 to 1996 HS codes, and all approvals for firms active from 2011-2015 to 2007 HS codes, in both cases using concordances from the UN Statistics Division. Before 1988, imports into the U.S. were classified using TSUS codes rather than HTSUS. I translate the former into the latter using concordances from Feenstra, Romalis, and Schott (2002). In all cases, when dealing with matches that are not one-to-one, I apportion codes based on a simple count of codes, so that the resulting datasets can have fractions of a code. When describing the set of possible active permissions 2011-2015, I include any code that concords at least in part to an approved component. HS codes that fall into Chapters 98 and 99 correspond to special rules, and are dropped as I do not have concordances across time that encompass these codes. Fortunately, these codes do not appear very often, and I successfully concord over 99.5% of all codes in applications.

A summary of sources (by type) and numbers of HS6 codes is provided in Table 3 in the main text.

Appendix 5.3: Other data for the cross-sectional regression:

Table 4 in the main text requires additional concordances and data. The unit of observation is an industry code in the 2007 BEA input-output table. I concord 2007 HS6 codes to the 2007 NAICS industry classifications (this includes many-to-many matches; I treat a NAICS code as having an approval if it matches at least to part of an approved HS6) using both data released by the U.S. Census in their Foreign Trade CDs (made available through Schott 2008) and also through the concordance made available in Pierce and Schott (2009). The NAICS industries are then concorded to the BEA industries.

This dataset also includes information on unskilled labor shares built on the classification system used in GTAP v7. In order to concord this data to the BEA input-output table, I use a concordance from the GTAP classification to the 2007 HS codes system available through the WITS database, and then concord the 2007 HS codes to the input-output table codes as described in the prior paragraph. Again, the concordances are many-to-many, so I take a weighted average of the relevant variables which map to a given input-output table code.

Appendix 5.4: Location dataset:

In order to construct Figure 2 in the main text, I geolocate each active zone (or part thereof). The Board's web site lists addresses for most general purpose zones and subzones. When this is insufficient, I turn to Federal Register notices and applications. Subzones and general purpose zones may be spread out across space; in this case, I attempt to locate all addresses corresponding to a location where manufacturing is taking place. Using these methods, I found address information for every active manufacturer, and geocoded these these addresses to obtain coordinates.

Appendix 5.5: Derivations:

In the text, I provide estimates of the fraction of U.S. manufacturing gross output and value added that was produced in SEZs. The FTZ Board Annual Reports to Congress declare the aggregate use of intermediates in manufacturing across all U.S. SEZs, and a range for intermediate use by each active firm. I took the average of the range within each firm and then re-weighted so that the sum of the average intermediate use corresponds to the aggregate intermediate use. I assume intermediate use within each firm is equally distributed across all approved outputs. I then concorded these outputs to the BEA input-output table and impute the relevant domestic value added.

In the text, I provide the figures that nearly one-eighth of all trade in the U.S. and over one-sixth of all trade that would be subject to taxes entered through the SEZ program as an input to manufacturing in 2014. The first of these figures is easily obtained: aggregate U.S. imports in 2014 were \$2.35 trillion, while imports through the U.S. SEZ program were \$288.3 billion (from the 2014 Annual Report to Congress). For the second, I use data on the U.S. Customs CDs, made available through Peter Schott's website (see: Schott, 2008). In these files, imports are partitioned by the relevant rate provision code – these codes describe the duty applied to the item – i.e. whether it paid a MFN tariff, a column 2 tariff, or entered through a number of other rates. There is a special code for trade flowing through SEZs and Bonded Warehouses. By comparing the total import volume using this code and reported imports from the Annual Report, I infer that over 98% of this trade is SEZ trade. I infer a taxable code if, within a given HTSUS8 there is any reported duty. I then find the total import volume in the HS8 that enters under taxable codes and the total volume that enters through SEZs. The SEZ share of taxed plus SEZ trade is 28.4%. Of this figure, some is distribution are warehousing; unfortunately, I do not know precisely how much. However, I know that 61% of all SEZ imports are used for manufacturing; I assume this ratio also holds true for trade in taxable lines, which implies 17.3% of all otherwise taxable trade flows through SEZs as an input to manufacturing.

In the text, I provide the figure that 70% of all taxable, imported intermediates to manufacturing entered through the SEZ program in 2014. I calculate this in several steps. First, I use the 2007 IO table to find the fraction of each industry that is used as an intermediate to manufacturing, and assume that the same proportion applies to traded goods. I then concord these codes to HS6 codes in 2014, and then find the quantity of taxed trade in these codes, and I find the inflow of goods to SEZs in these goods. I assume the same ratio between manufacturing and distribution warehousing holds for these goods as it does overall, and thus find both a quantity of taxable trade and a volume of SEZ manufacturing intermediates. The figure rises to 83% of manufacturing intermediates entering duty reduced if I also account for goods duty-reduced through other programs (e.g. free-trade agreements or temporary tariff suspensions). This second number might be the theoretically correct one: the government cannot let in more than 100% of imports of a given intermediate enter at reduced duty, regardless of which program it enters through. As a result, only considering SEZ trade understates how close the government is able to get to entering all imports at a reduced duty.

I also consider how this figure changes if I make different assumptions about what fraction of SEZ entries in non-dutiable lines (which is small but not zero) comes from distribution and warehousing as opposed to manufacturing. If all zero-tariff entries are from manufacturing, then the estimated SEZ share of manufacturing intermediates falls to 61% (if I include other programs, then this share rises to 78%). If all zero-tariff entries are from distribution and warehousing, then the number rises to 84% (if I include other programs, then this share rises to 91%).

Finally, in the text I provide the figure (for 2011-2015) that \$17.1 billion in duties are forgiven or deferred through the SEZ program (counting both manufacturing and distribution/warehousing) and \$2.86 billion in tariff revenue are forgiven through the manufacturing arm alone. The first figure is easily obtained from the the U.S. Customs CDs (Schott (2008)) by using the rate provision codes – I can infer average MFN tariffs at the tariff-line level and the volume of imports within a tariff line which enter a SEZ. For the second figure, I again start with the Customs CDs. These files report both "General Imports" and also "Imports for Consumption". "Imports for Consumption" are imports that do not enter SEZs, plus SEZ outputs (technically, the foreign value added thereof). "General Imports" represents imports that do not enter SEZs plus imports to SEZs. Thus, by taking the difference, I can find the net contribution of SEZs in a given good. For some goods this balance is positive, while for others it is negative. If the value of goods stored in SEZs never changed, then this would capture the impact of SEZ year-by-year. Unfortunately, this is not a good assumption. For years 2010 and earlier, the annual reports reveal the exact quantity of imports and shipments (outflows) from every SEZ, and there is not good balance. (I cannot use these data for this purpose as they do not distinguish between manufacturing and distribution/warehousing). To account for this, I combine the data for a five-year period; although the inflows and outflows may still not be balanced, it is likely to be a much smaller fraction of the total. I then infer average duty rates at the HS8 level; this gives figures for total forgiven revenue (across both manufacturing and warehousing/distribution). However, part of this revenue reflects exports from distribution/warehousing. I use the Board's Annual Reports to apportion exports across distribution/warehousing and manufacturing, and assume that a constant share of all codes with net consumption of goods through SEZs reflects distribution/warehousing exports.

References

Anderson, James E., and J. Peter Neary. 1994. "Measuring the Restrictiveness of Trade Policy." *The World Bank Economic Review*, 8(2): 151–169.

Anderson, Simon P., Andre De Palma, and Jacques-Francois Thisse. 1989. "Demand for Differentiated Products, Discrete Choice Models, and the Characteristics Approach." *The Review of Economic Studies*, 56(1): 21–35.

Creskoff, Stephen, and Peter Walkenhorst. 2009. "Implications of WTO Disciplines for Special Economic Zones in Developing Countries."

de Almeida, Maria Candida Carvalho Monteiro. 2016. "Export Processing Zones and the Law of the World Trade Organization." *University of Brasilia Law Journal (Direito. UnB)*, 1(2).

Engman, Michael, Osamu Onodera, and Enrico Pinali. 2007. "Export Processing Zones: Past and Future Role in Trade and Development." OECD Publishing 53.

Flam, Harry, and Elhanan Helpman. 1987. "Industrial policy under monopolistic competition." *Journal of International Economics*, 22(1): 79–102.

Granados, Jaime. 2002. "Export processing zones and other special regimes in the context of multilateral and regional trade negotiations." Inter-American Development Bank, Washington, D.C. Google-Books-ID: 60i5R0NhG14C.

Helpman, Elhanan. 1981. "International trade in the presence of product differentiation, economies of scale and monopolistic competition: A Chamberlin-Heckscher-Ohlin approach." *Journal of International Economics*, 11(3): 305–340.

Laird, Sam. 1997. "WTO rules and good practice on export policy." WTO Staff Working Paper Working Paper TPRD-97-01.

Lancaster, Kelvin J. 1966. "A New Approach to Consumer Theory." *Journal of Political Economy*, 74(2): 132–157.

Ludema, Rodney D., and Anna Maria Mayda. 2013. "Do terms-of-trade effects matter for trade agreements? Theory and evidence from WTO Countries*." *The Quarterly Journal of Economics*, 128(4): 1837–1893.

McGilvray, Andrew. 2004. "Enhancing the foreign-trade zones program for small and medium-sized manufacturers." Foreign Trade Zones Board.

New and Full Notification Persuant to Article XVI:1 of the GATT 1994 and Article 25 of the Agreement on Subsidies and Countervailing Measures: United States. 2015*a*. "New and Full Notification Persuant to Article XVI:1 of the GATT 1994 and Article 25 of the Agreement on Subsidies and Countervailing Measures: United States." World Trade Organization Committee on Subsidies and Countervailing easures G/SCM/N/284.

Pierce, Justin R., and Peter K. Schott. 2009. "Concording U.S. Harmonized System Categories Over Time."

Schott, Peter K. 2008. "The relative sophistication of Chinese exports." *Economic Policy*, 23(53): 6–49.

Semi-Annual Reports Under Article 25.11 of the Agreement: United States. 2016. "Semi-Annual Reports Under Article 25.11 of the Agreement: United States." World Trade Organization Committee on Subsidies and Countervailing Measures G/SMC/N/305.

Torres, Raul A. 2007. "Free Zones and the World Trade Organization Agreement on Subsidies and Countervailing Measures." *Global Trade and Customs Journal*, 2: 217–224.

Trade Policy Review: Report by the Secretariat: United States. 2008. "Trade Policy Review: Report by the Secretariat: United States." World Trade Organization Trade Policy Review Body WT/TPR/S/200/Rev. 1.

Trade Policy Review: Report by the Secretariat: United States. 2013. "Trade Policy Review: Report by the Secretariat: United States." World Trade Organization Trade Policy Review Body WT/TPR/S/275/Rev. 2.

Trade Policy Review: Report by the Secretariat: United States. 2015*b*. "Trade Policy Review: Report by the Secretariat: United States." World Trade Organization Trade Policy Review Body WT/TPR/S/307/Rev. 1.

Waters, James J. 2013. "Achieving World Trade Organization Compliance for Export Processing Zones While Maintaining Economic Competitiveness for Developing Countries Note." *Duke Law Journal*, 63: 481–524.