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Industrialisation and the Big Push in a Global Economy*

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Abstract

In this paper, we develop a multi-country open economy extension of the famous Big Push model for a closed economy by Murphy et al. (1989). We show under which conditions the global economy in our model is caught in a poverty trap, characterised by a low-income equilibrium from which an escape is possible (only) via a coordinated modernization effort across sectors and countries. We also analyze to what extent the degree of openness matters for the prospects of achieving the high-income equilibrium. We show that under monopolistic competition with CES preferences the openness to international trade does not affect the set of parameter combinations leading to a poverty trap, whereas international trade makes it more difficult to achieve industrialisation through a Big Push with continuum quadratic preferences. Responsible for this adverse outcome is the pro-competitive effect of opening up to international trade, which bites into firms' profit margins, rendering the adoption of a superior production technology unprofitable as it becomes more difficult for firms to amortise their adoption fixed costs.

JEL-Classification: F12, O14, F43

Keywords: Big Push, multiple equilibria, backward linkages, international trade, globalisation, poverty trap, technology upgrading, monopolistic competition

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1 Introduction

"Let us assume that 20,000 unemployed workers [...] are taken from the land and put into a large shoe factory. They receive wages substantially higher than their previous meagre income in natura. [...] If these workers spent all their wages on shoes, a market for the products of their enterprise would arise [...]. The trouble is that the workers will not spend all their wages on shoes."

"If, instead, one million unemployed workers were taken from the land and put, not into one industry, but into a whole series of industries which produce the bulk of the goods on which the workers would spend their wages, what was not true in the case of one shoe factory would become true in the case of a whole system of industries: it would create its own additional market, thus realising an expansion of world output with the minimum disturbance of the world markets."

(Rosenstein-Rodan, 1943, pp. 205-206)

Rosenstein-Rodan's (1943) story of a shoe factory is often regarded as the description of a prototypical poverty trap. In the terminology of Hirschman (1958), it can be interpreted as a story of backward linkages between industries: The extra wage income generated in the modernising sector is only partially spent on goods produced in the sector itself, and hence the modernisation leads – via pecuniary spillovers – to an outward shift in the demand curves of other sectors.[1] At the same time, these pecuniary spillovers and the loss of purchasing power to the modernising sector that go with it, are the very reason why the shoe factory quite possibly cannot break even by itself. But if modern firms in other sectors were established, they would generate their own pecuniary externalities, this time to the benefit of – among others – the shoe factory. A coordinated "Big Push" towards modernisation across all sectors could therefore be achievable, while each sector on its own would be bound to fail in its effort to modernise.

The first, and widely celebrated, formalisation of the Big Push story by Rosenstein-Rodan (1943) is due to Murphy et al. (1989).[2] Theirs is a model of a closed economy in which – true to the quote from above – workers in a modern sector producing with increasing returns to scale earn a wage premium relative to traditional employment opportunities. Murphy et al. (1989) show that their model can generate a coexistence of a low-income equilibrium in which no firm modernises with a high-income equilibrium in which production in all sectors happens with the modern technology. When high- and low-income equilibria co-exist, the high-income equilibrium can be reached if a sufficiently large number of sectors coordinate their modernisation efforts,

[1]See Krugman (1993) for a formal definition of backward and forward linkages, according to which industries have backward linkages when their demand makes it easier for an upstream industry to reach a sustainable scale. In the example of the shoe factory, the additional income benefits other producers of consumer goods instead of upstream firms, but the mechanism is the same. By contrast, an industry with forward linkages reduces the costs of downstream industries via a decrease in its prices.

[2]See Krugman (1993) for a critical acclaim of the Murphy-Shleifer-Vishny model, which lead to a revival of what Krugman (1993) subsumed under the term "high development theory" (cf. Rosenstein-Rodan, 1943; Nurkse, 1952; Fleming, 1955). Surveys of the poverty trap literature have been provided among others by Azariadis and Stachurski (2005), Matsuyama (2008) as well as Kraay and McKenzie (2014).

where the mechanism follows exactly the logic laid out by Rosenstein-Rodan (1943).

Murphy et al. (1989) are very clear in their paper that the assumption of a closed economy – or at least of an economy that cannot trade freely with the rest of the world – is crucial for their model to work. In line with this reasoning, they devote a whole section of their paper to "The importance of domestic markets". Whether or not as a consequence of the explicit focus in Murphy et al. (1989) on a closed economy, the subsequent literature on backward linkages and economic development followed their example (cf. Matsuyama, 1992; Yamada, 1999; Ciccone, 2002; Mehlum et al., 2003). In this paper we set ourselves a straightforward task: to develop an open-economy version of the Murphy-Shleifer-Vishny model. There are three reasons why we think this contribution is valuable. First, we think that the focus of the analysis on a closed economy is much harder to defend today than it was for Murphy, Shleifer and Vishny 30 years ago (Head and Mayer (2013) compute trade openness at a global scale and document a 18 percentage point increase from 12% in 1960 to 30% in 2011). Second, it is far from obvious to us that the possibility of a low-income trap due to backward linkages and demand spillovers disappears in an open economy. After all, openness to international trade not only leads to a larger potential customer base, but also to a situation in which more firms are competing for those very customers, with the net effect on the effective market size for an individual firm ex ante ambiguous. And third, it is clear from the quote above that in looking at an economy that is open to international trade we are getting closer to the original idea of Rosenstein-Rodan (1943), who was thinking of the size of "world markets", not the size of national markets, as being relevant for the possibility of a low-income trap.

In the model of Murphy et al. (1989), a single firm in each sector can upgrade its traditional constant-returns-to-scale (CRS) technology to a modern increasing-returns-to-scale (IRS) technology, becoming a limit-pricing monopolist, who is disciplined only by a competitive fringe of firms that continue to use the traditional CRS technology. Due to the assumption that modern firms have to pay higher wages, modernisation in an individual sector increases aggregate demand even if the individual firm suffers a loss from adopting the modern technology. If technology upgrading decisions are coordinated across sectors, these mutually beneficial demand spillovers can be fully internalised, giving rise to the possibility that collective technology upgrading is individually profitable for all firms even though individual technology upgrading is not.

In order to make Murphy et al.'s (1989) closed-economy model of a Big Push amenable for an open-economy analysis, we borrow from the international trade literature, and assume a market structure that is characterised by monopolistic competition among a given number of horizontally differentiated producers. As a consequence, modern and traditional firms can coexist while charging different prices, which – unlike in Murphy et al. (1989) – depend on the full general equilibrium of the model. As a consequence, our model features a new equilibrium type. In addition to the two polar cases familiar from Murphy et al. (1989), in which the modern IRS technology is adopted either in no sector or simultaneously by all sectors, there also is the possibility of an equilibrium with incomplete industrialisation, in which the IRS technology is adopted only by a subset of all firms.[3] The decoupling of prices across firm types thereby matters in two ways: On the one hand, adopters of the modern IRS technology can now divert expenditure away from other firms by charging lower prices. On the other hand, wages are increasing in the number of firms that choose the modern technology. Both effects have the consequence of reducing the gains from modernisation as the modern IRS technology is adopted by more and more firms, an equilibrium in which technology adoption pays off only for a subset of firms.

In order to effectively illustrate the outcomes of our model despite the added complexity, we develop a new graphical representation that allows us to decompose the model's admissible parameter space into mutually exclusive parameter regions that are associated with the various model outcomes. Our newly developed graphical tool thereby proves particularly useful in isolating parameter regions that give rise to a poverty trap, both in the case of a multi-country world economy featuring trade between the countries and in a counterfactual situation in which all countries are in autarky. We can furthermore use our approach to study how the chances of escaping from a poverty trap are affected by the forces of globalisation. We find that a country's chances of escaping from a poverty trap crucially depend on how globalisation affects the ability of firms to cover the fixed costs associated with the adoption of a superior production technology. Because market shares and operating margins are differentially affected by globalisation, we begin by deriving an intuitive neutrality condition, under which openness has no effect on how easy it is to escape from a poverty trap. We show that in the standard model of monopolistic competition with textbook CES preferences (cf. Dixit and Stiglitz, 1977) constant mark-ups and a proportional pass through ensure that this neutrality condition is fulfilled. By contrast, in the case of continuum quadratic preferences (cf. Melitz and Ottaviano, 2008) international trade renders the coordinated adoption of the modern technology by means of a Big Push more difficult since trade has a pro-competitive effect, leading to a decline in firms' operating margins.

By incorporating backward linkages in the spirit of Rosenstein-Rodan (1943) and Murphy et al. (1989) into an open-economy model we complement a rich literature on multiple equilib-

[3] See Paternostro (1997) for a model of poverty traps, in which equilibria with incomplete industrialisation are derived under the additional assumption of a positive fixed cost externality.

ria in the open economy that analyzes the role of forward (instead of backward) linkages (cf. Krugman and Elizondo, 1996; Rodriguez-Clare, 1996; Rodrik, 1996; Sachs and Warner, 1999; Trindade, 2005). Krugman and Elizondo (1996) thereby focus on multiple spatial equilibria within a New Economic Geography (NEG) model (cf. Krugman, 1991) and show that the multiplicity of equilibria is eliminated if the economy becomes sufficiently open for international trade. According to Sachs and Warner (1999) the relative strength of (external) increasing returns to scale in non-traded versus traded goods industries determines whether a resource boom can substitute for a Big Push. Trindade (2005) uses a model with external increasing returns to scale in the production of tradable intermediates to show that the lifting-all-boats effect of export-promoting policies can push an economy from a low- to a high-welfare equilibrium.

Our model's stylized representation of a global poverty trap in a internationalised world economy moreover can be linked to the ongoing discourse about the right timing for switching to a clean technology as the currently most prominently discussed example for a globally coordinated transition to a more advanced technology (cf. Acemoglu et al., 2016; Aghion et al., 2016). In the context of this debate, our result of multiple equilibria that emerge at a global rather than at a national scale should be understood as an advocacy for international cooperation and against uncoordinated national initiatives.

The paper is structured as follows: In Section 2 we provide a short summary of Murphy et al.'s (1989) original model, introducing a new graphical tool in the process that we also use for the analysis of our own model later on. Section 3 introduces the main building blocks of our model and derives a general solution strategy. In Sections 4 and 5 we then explicitly solve our model for CES and continuum quadratic preferences. Section 6 concludes.

2 The Big Push Model of Murphy, Shleifer, and Vishny

We begin our analysis with a short presentation of the Big Push model by Murphy et al. (1989). Consider a closed economy with a continuum of sectors $z \in [0, 1]$ and Cobb Douglas utility $U[x(z)] = \exp[\int_0^1 \ln x(z)dz]$, in which $x(z)$ denotes consumption of good z. The economy is endowed with a fixed supply of labour $L > 0$, which also serves as *numéraire*, implying unitary wages $w = 1$. In each sector a competitive fringe of firms has access to a traditional technology $y_T(z) = l_T(z)$ (denoted by superscript T) with a unitary labour input coefficient. A single one of those firms in each sector also has access to a modern technology with increasing returns to scale (denoted by superscript M), which is characterised by production function $y_M(z) = \max\{0, [l_M(z) - F]/\delta\}$, with $\delta \in (0, 1)$ as marginal labour requirement, and $F \in (0, L)$ as fixed labour requirement. To adopt the modern technology and to become a monopolist, firms in each sector have to pay an exogenously given (multiplicative) wage premium $v > 1$.

We follow the exposition of the model in Krugman (1993) and define per-capita variables $\tilde{y}(z) \equiv y(z)/L$ and $f \equiv F/L$. Adopting the modern technology throughout the economy constitutes a Pareto improvement if and only if modernization leads to an increase in per-capita output. When all sectors are modernised, labour is equally distributed among the sectors, and we have

$$\tilde{y}_M(z) = \frac{1}{\delta}\frac{L-F}{L} = \frac{1-f}{\delta}.$$

Since the traditional technology delivers a per-capita output of 1, the condition for a Pareto improvement via the modern technology can be written as $(1-f)/\delta > 1$, or alternatively, $f+\delta < 1$. The latter inequality has a very intuitive interpretation: With the modern technology, $f+\delta$ labour units are necessary to produce one unit of output per capita. If and only if this is less than the respective labour requirement under the traditional technology is the modern technology preferable on welfare grounds.

The famous result of Murphy et al. (1989) is that with $v > 1$ the potential for a poverty trap exists, where a poverty trap is defined as a situation with multiple equilibria in which industrialisation

(i) would constitute a Pareto improvement,

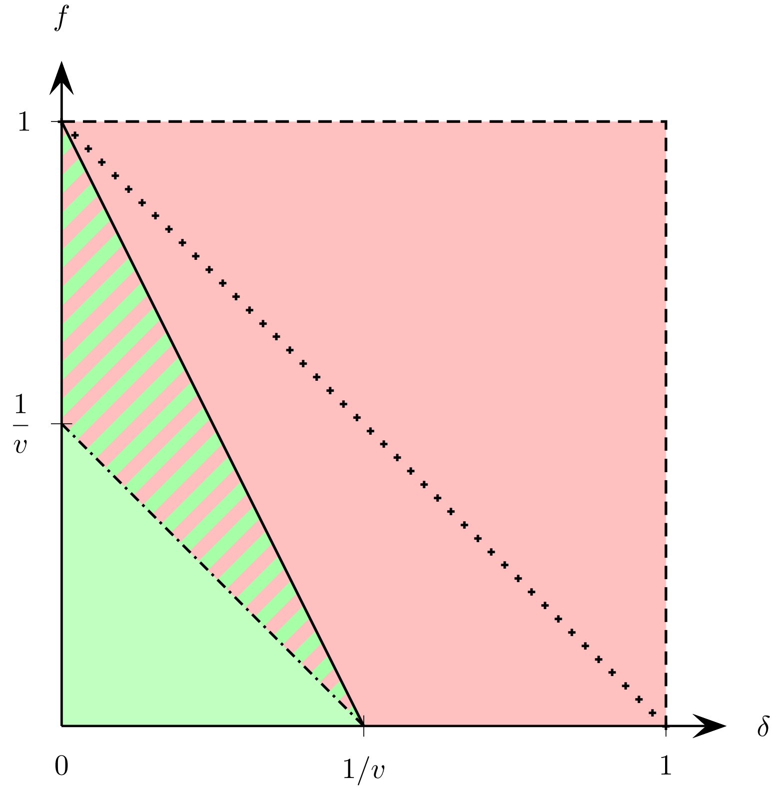
(ii) is not profitable for individual firms, and therefore does not happen, in a decentralised equilibrium,

(iii) is profitable for all firms, and therefore does happen, if industrialisation is coordinated across sectors.

To illustrate this result, suppose a single firm in a particular sector starts to modernise. The modern firm charges the same unitary (limit) price as the traditional firms and sells the same quantity $\tilde{y}_T(z) = \tilde{y}_M(z) = 1$ (each sector only marginally contributes to the economy as a whole such that income effects are absent in this case). To produce this quantity the modern firm incurs labour cost $(f+\delta)v$, which may be larger than 1, thereby rendering modernisation by a single firm unprofitable, even though $f+\delta < 1$ and therefore modernisation in all sectors would be Pareto efficient.

Now suppose firms in all sectors modernise simultaneously. This move increases aggregate demand, letting all firms produce output (equal to revenue) $\tilde{y}_M(z) = (1-f)/\delta$, while labour cost is equal to v. With $(1-f)/\delta > v$, simultaneous modernisation of all sectors is profitable. Putting together the parameter constraints, multiple equilibria occur in Murphy et al. (1989)

Figure 1: *Multiple versus Unique Equilibria*



for:

$$1 - \delta v > f > \frac{1 - \delta v}{v}, \tag{1}$$

in which the first inequality ensures that coordinated modernisation is profitable, whereas the second inequality ensures that individual modernisation is not profitable. The exogenous wage premium $v > 1$ is crucial for the existence of multiple equilibria, since it gives rise to a pecuniary demand externality that is rationally ignored by individual firms, implying that all firms underinvest into the adoption of the modern technology. By coordinating their technology choices across the continuum of sectors, firms contribute equally to an increase in aggregate demand, and they also share the benefits. As a consequence, the adoption of the Pareto superior modern technology is profitable for each single firm as long as f is in the interval given by the inequality from Eq. (1).

In Figure 1 we propose a novel diagrammatic representation of multiple equilibria, which depicts the boundary condition $f = 1 - \delta v$ as a black solid line, and the boundary condition $f = (1 - \delta v)/v$ as a black dot-dashed line. Combinations of f and δ between both lines lead to multiple equilibria as described. In the red parameter space no sector modernises, while industrialisation always succeeds in the green parameter space. For the multiplicity of equilibria in Figure 1 to qualify as a poverty trap, aggregate welfare in the industrialised equilibrium has to be higher than in the non-industrialised equilibrium, which is the case for $f + \delta < 1$. The boundary condition $f + \delta = 1$ is given by the main diagonal in Figure 1, confirming that parameter combinations in the area with green stripes give rise to a poverty trap.

3 A General Model of the Big Push in a Global Economy

In order to make the Big Push model by Murphy et al. (1989) amenable to open economy analysis in a straightforward way, we introduce horizontal product differentiation at the sector level, with domestic and foreign varieties of the same good being imperfect substitutes for each other.[4] Our model shares the property that poverty traps arise due to the co-existence of pecuniary externalities between sectors (backward linkages) and increasing returns to scale at the firm level. We stick to the assumption from Murphy et al. (1989) that firms face a binary choice between CRS and IRS technologies, and introduce this assumption into a symmetric general equilibrium monopolistic competition model with a given number of firms in each country.

We consider a stylized world economy with $N + 1 \geq 1$ symmetric countries, each with a continuum of sectors $z \in [0, 1]$ and a continuum of firms on a unit interval $\omega(z) \in [0, 1]$ within each sector z.[5] Firms compete under monopolistic competition and have the choice between two technologies: a traditional CRS technology (indexed by subscript T) with a unitary labour input coefficient and a modern IRS technology (indexed by subscript M) with variable labour requirement $\delta \in (0, 1]$ and fixed labour requirement $F \in (0, L]$. The two production technologies in our model are the same as in Murphy et al. (1989), and therefore both models also share the condition for the modern technology to be preferable on welfare grounds: Adopting the modern technology increases aggregate welfare if and only if $f + \delta < 1$, i.e. if the number of labour units necessary to produce one unit of output per capita is reduced by modernization.

[4] Murphy et al.'s (1989) clever combination of asymmetric Bertrand competition and Cobb-Douglas demand, which greatly simplifies the analysis of the closed-economy model, at the same time immensely complicates the incorporation of international trade: Quasi-rents from technology adoption and therefore the incentives to modernise are eliminated if two or more modern firms from different countries compete over the prices of homogeneous goods. With free trade and identical technologies everywhere we therefore end up in the Bertrand paradox. In the presence of non-prohibitive (variable) trade costs modern firms in each country would resort to a limit pricing strategy, slightly undercutting the foreign competitors' unit costs. With entry into the foreign market being effectively blocked, investments into modern IRS technologies would be again constrained by the (initial) size of the domestic market, potentially giving rise to multiple equilibria in the open economy. As an obvious drawback of this modelling strategy the open-economy equilibrium would feature zero international trade (cf. Neary and Leahy, 2015).

[5] Note that under monopolistic competition firms are small relative to the rest of the economy. As a consequence, we could suspense the sector continuum, which (Murphy et al., 1989) introduced in order to model oligopolistic competition in general equilibrium (see also Neary (2003), whose General Oligopolistic Equilibrium (GOLE) concept is built on the same assumption). Because the single-sector version of our model is isomorphic to a model version with a continuum of sectors that is defined on a unit interval, we maintain the continuum of sectors, which allows us to discuss not only intra-sectoral but also inter-sectoral demand spillovers, which are at the heart of Rosenstein-Rodan's (1943) and Murphy et al.'s (1989) argumentation.

Labour is the only factor of production and countries' aggregate labour supply is exogenously given by $L > 0$. As in Murphy et al. (1989), firms using the modern technology have to pay an exogenous wage premium $v > 1$. International trade in horizontally differentiated products is subject to iceberg-type trade cost $\tau \geq 1$.

The existence of multiple equilibria in our open economy model hinges on two conditions that are directly analogous to those in the original Big-Push model: industrialisation is not profitable for an individual firm, but coordinated action across all sectors and countries makes industrialisation worthwhile for all firms. In this section, we derive general expressions for firm profits as functions of firm-level performance measures (operating margins and revenues), and of one key general equilibrium variable (the wage rate). In the following sections we then derive specific closed-form solutions for these variables under two different assumptions concerning consumer preferences.

The two most interesting equilibria of our model are completely symmetric, with either all firms using the traditional technology, or all firms using the modern one. We distinguish between both situations notationally by using a hat "$\frown$" over a variable to denote the traditional equilibrium and a check "$\smile$" over a variable to denote the modern one.[6] Since individual firms in the continuum have measure zero, subscripts $i \in \{T, M\}$ (to indicate the status of a single firm) and accents (to indicate the status of the continuum of firms) can be used independently from each other. Denoting firm-level profits by Π, we therefore write $\widehat{\Pi}_T$ for the profits of a traditional firm in a continuum in which all firms use the traditional technology, and $\widehat{\Pi}_M$ for the profits of a modern firm in a continuum in which all other firms use the traditional technology. The analogous variables for profits of an individual traditional (respectively modern) firm in a continuum of modern firms are $\check{\Pi}_T$ and $\check{\Pi}_M$.

A situation with multiple equilibria requires, as in Murphy et al. (1989), that two inequalities regarding firm-level profits hold at the same time. First, it must be the case that individual industrialisation is not profitable, i.e. $\widehat{\Pi}_M < \widehat{\Pi}_T$. Second, joint modernisation by all firms (i.e. industrialisation) must be profitable, i.e. $\check{\Pi}_M > \widehat{\Pi}_T$.

Profits of a traditional, respectively modern, firm in the traditional equilibrium are given by:

$$\widehat{\Pi}_T = \hat{\pi}_T + N\hat{\pi}_T^* = \hat{\mu}_T\hat{\theta}\widehat{E} + \hat{\mu}_T^*(1-\hat{\theta})\widehat{E}^*, \tag{2}$$

$$\widehat{\Pi}_M = \hat{\pi}_M + N\hat{\pi}_M^* = \hat{\mu}_M\hat{\theta}\hat{\eta}\widehat{E} + \hat{\mu}_M^*(1-\hat{\theta})\hat{\eta}^*\widehat{E}^* - v\hat{w}F, \tag{3}$$

[6] This notation, we hope, is easy to remember if one associates the respective accent with the shape of a particular roof: the hat "$\frown$" is reminiscent – at least to us – of a traditional gable roof, while we find the check "$\smile$" to be reminiscent of a more modern butterfly roof.

in which $\hat{\mu}_i \equiv \hat{\pi}_i/\hat{r}_i \in (0,1)$ is the operating margin of firm type $i \in \{T, M\}$, whereas $\hat{\theta} \equiv \hat{r}_T/(\hat{r}_T + N\hat{r}_T^*) \in [0,1]$ denotes the domestic expenditure share. We moreover introduce $\hat{\eta} \equiv \hat{r}_M/\hat{r}_T$ and $\hat{\eta}^* \equiv \hat{r}_M^*/\hat{r}_T^*$ to denote the revenue boost from unilateral modernization. Aggregate expenditures are given by $\widehat{E} = \hat{r}_T + N\hat{r}_T^*$, and we have $\widehat{E} = \widehat{E}^*$ due to symmetry. Aggregate income $\widehat{Y}$ is the sum of profit income and labour income, and hence the following accounting identity holds: $\widehat{Y} = \widehat{\Pi}_T + \hat{w}L$. Substituting $\widehat{\Pi}_T$ from Eq. (2), and using the balanced trade condition $\widehat{Y} = \widehat{E} = \widehat{E}^*$, we get:

$$\widehat{Y} = \widehat{A}\hat{w}L \quad \text{with} \quad \widehat{A} \equiv \frac{1}{1 - [\hat{\theta}\hat{\mu}_T + (1-\hat{\theta})\hat{\mu}_T^*]}. \tag{4}$$

The multiplier $\widehat{A}$ thereby indicates by how much aggregate income $\widehat{Y}$ exceeds labour income $\hat{w}L$ due to the presence of aggregate profit income $\widehat{\Pi}_T$, and Eq. (4) shows that it depends on a weighted average of the domestic and foreign profit margins, with domestic and foreign expenditure shares as the weights. Substituting aggregate income back into Eqs. (2) and (3), using again the balanced trade condition, we can express the profit gain from modernization for an individual firm as:

$$\widehat{\Pi}_M - \widehat{\Pi}_T = \{\hat{\mu}_M\hat{\theta}\hat{\eta} + \hat{\mu}_M^*(1-\hat{\theta})\hat{\eta}^* - [\hat{\mu}_T\hat{\theta} + \hat{\mu}_T^*(1-\hat{\theta})](1-vf) - vf\}\widehat{A}\hat{w}L. \tag{5}$$

As in Murphy et al. (1989) we find that individual modernisation is more likely to be profitable if the fixed labour requirement $f \equiv F/L$ associated with the adoption of the modern technology and the exogenous wage premium $v > 1$ are not too high. Also, and quite intuitively, individual modernisation is more likely to succeed if there is a – preferably large – modernization-induced increase in operating margins and/or in firm-level revenues. The degree of openness, which is inversely related to the domestic expenditure share $\hat{\theta}$, only matters for the sign of $\widehat{\Pi}_M - \widehat{\Pi}_T$ if $\hat{\mu}_i \neq \hat{\mu}_i^*$ and $\hat{\eta}_M \neq \hat{\eta}_M^*$ depend on $\hat{\theta}$.

Coordinated modernization of all firms leads to firm-level profits of:

$$\breve{\Pi}_M = \breve{\pi}_M + N\breve{\pi}_M^* = \breve{\mu}_M\breve{\theta}\breve{E} + \breve{\mu}_M^*(1-\breve{\theta})\breve{E}^* - v\breve{w}F, \tag{6}$$

in which $\breve{\mu}_M \equiv \breve{\pi}_M/\breve{r}_M \in (0,1)$ corresponds to the operating margin of firms producing with the modern technology when all do so, whereas $\breve{\theta} \equiv \breve{r}_M/(\breve{r}_M + N\breve{r}_M^*) \in [0,1]$ denotes the domestic expenditure share. Aggregate expenditures are equal to $\breve{E} = \breve{r}_M + N\breve{r}_M^*$ with $\breve{E} = \breve{E}^*$ due to symmetry. With all firms using the modern technology, the accounting identity for aggregate income becomes $\breve{Y} = \breve{\Pi}_M + v\breve{w}L$

Substituting $\breve{\Pi}_M$ from Eq. (6), using the balanced trade condition $\breve{Y} = \breve{E} = \breve{E}^*$, we obtain:

$$\breve{Y} = \breve{A} v \breve{w} (1-f) L \quad \text{with} \quad \breve{A} \equiv \frac{1}{1 - [\breve{\theta}\breve{\mu}_M + (1-\breve{\theta})\breve{\mu}^*_M]}. \tag{7}$$

The multiplier $\breve{A}$ thereby indicates by how much aggregate income $\breve{Y}$ exceeds the aggregate labour income of production workers $v\breve{w}(1-f)L$ due to the presence of aggregate profit income $\breve{\Pi}_M$ and labour income paid out to non-production workers $v\breve{w}F$. Substituting aggregate income back into Eq. (6), using again the balanced trade condition, we can express the profit gain for an individual firm as a consequence of coordinated modernization as:

$$\breve{\Pi}_M - \widehat{\Pi}_T = [\breve{\mu}_M \breve{\theta} + \breve{\mu}^*_M (1-\breve{\theta}) - f] v \breve{w} \breve{A} L - [\hat{\mu}_T \hat{\theta} + \hat{\mu}^*_T (1-\hat{\theta})] \hat{w} \widehat{A} L. \tag{8}$$

Not surprisingly, the condition for a coordinated modernisation across all sectors to be profitable is more likely to be met under conditions that are similar to those for successful unilateral modernization (low fixed costs of modernization, large positive effects of modernization on firm-level revenues and/or operating margins). In contrast to the case of unilateral modernization, we also find that the wage rates $\hat{w}$ and $\breve{w}$ and the multipliers $\widehat{A}$ and $\breve{A}$ play an important role, with the ratio $v\breve{w}\breve{A}/\hat{w}\widehat{A}$ capturing the magnitude of the mutual demand spillovers between firms and sectors. The degree of openness, which is inversely related to the domestic expenditure share $\hat{\theta}$, only matters for the sign of $\breve{\Pi}_M - \widehat{\Pi}_T$ if $\breve{w}/\hat{w}$, $\hat{\mu}_T \neq \hat{\mu}^*_T$ and $\breve{\mu}_M \neq \breve{\mu}^*_M$ depend on θ.

We are now in a position to formulate the following proposition:

Proposition 1 *In the open economy, multiple equilibria, characterised by no versus complete industrialisation, exist if* $\widehat{\Pi}_M - \widehat{\Pi}_T < 0$ *and* $\breve{\Pi}_M - \widehat{\Pi}_T > 0$, *with the respective profit differences characterised by Eqs.* (5) *and* (8).

Proof Formal derivation and discussion in the text. ■

In addition to the equilibria types discussed so far, which are known in principle from Murphy et al. (1989), our model also features an equilibrium with incomplete industrialization, in which a subset of firms in all countries and sectors choose the modern technology, while others stick to the traditional one. In order for this equilibrium to exist, unilateral modernization has to be profitable, i.e. $\widehat{\Pi}_M - \widehat{\Pi}_T$, determined by Eq. (5) must be positive. On the other hand, it must be true that modernization is not profitable for the last firm to do so. In order to express this condition formally, we define, in analogy to $\widehat{\Pi}_M$ $\widehat{\Pi}_T$, and $\breve{\Pi}_M$, the profits of a firm that unilaterally uses the traditional technology in a modern equilibrium by:

$$\breve{\Pi}_T = \breve{\pi}_T + N\breve{\pi}_T^* = \breve{\mu}_T\breve{\theta}\breve{\eta}\breve{E} + \breve{\mu}_T^*(1-\breve{\theta})\breve{\eta}^*\breve{E}^*, \tag{9}$$

with $\breve{\eta} \equiv \breve{r}_T/\breve{r}_M$ and $\breve{\eta}^* \equiv \breve{r}_T^*/\breve{r}_M^*$ as the revenue squeezes experienced by a firm at home and abroad, respectively, as a consequence of adopting the traditional technology in an equilibrium in which all other firms are modern. In analogy to above, we can now write the profit gain from modernization for the last firm doing it as:

$$\breve{\Pi}_M - \breve{\Pi}_T = \{\breve{\mu}_M\breve{\theta} + \breve{\mu}_M^*(1-\breve{\theta}) - [\breve{\mu}_T\breve{\theta}\breve{\eta} + \breve{\mu}_T^*(1-\breve{\theta})\breve{\eta}^*](1-f) - f\}\breve{A}v\breve{w}L. \tag{10}$$

An equilibrium with partial modernization exists if the difference in Eq. (10) is negative, i.e. if it is not worthwhile to be a modern firm in a situation in which everybody else is.

In the following we will explicitly solve our generalised version of Murphy et al.'s (1989) Big Push Model for two different demand systems (with iso-elastic and linear demand functions). We do so to (*i*) prove the existence of poverty traps in the open economy, (*ii*) to characterise and illustrate the admissible parameter space for which a poverty trap can arise, and (*iii*) to understand how this parameter space depends on the openness to international trade. In analogy to Figure 1, we solve for the three profit differentials in Eqs. (5), (8), and (10) in terms of model parameters and graph the boundary conditions $\widehat{\Pi}_M = \widehat{\Pi}_T$, $\breve{\Pi}_M = \widehat{\Pi}_T$, and $\breve{\Pi}_M = \breve{\Pi}_T$, along with the condition for Pareto-improving technology adoption, $f + \delta < 1$, in $f - \delta$ space. This way, we can depict parameter combinations that give rise to each possible equilibrium configuration, and we can explore to what extent these boundary conditions – and therefore the likelihood of a poverty trap – depend on the degree of openness.

Eqs. (5), (8), and (10) reveal a set of straightforward sufficient conditions under which these boundary conditions are unaffected by globalisation, as measured by, and inversely related to, the domestic expenditure share θ:

Corollary 1 *A set of sufficient conditions for the degree of openness to have no effect on the boundary conditions* $\widehat{\Pi}_M = \widehat{\Pi}_T$, $\breve{\Pi}_M = \widehat{\Pi}_T$, *and* $\breve{\Pi}_M = \breve{\Pi}_T$ *is given by:*

(a) $\hat{\mu}_i = \hat{\mu}_i^*$ *and* $\breve{\mu}_i = \breve{\mu}_i^*$ $\forall\ i \in \{T, M\}$ *both independent of* θ*,*

(b) $\hat{\eta}_M = \hat{\eta}_M^*$ *and* $\breve{\eta}_T = \breve{\eta}_T^*$ $\forall\ i \in \{T, M\}$ *both independent of* θ*,*

(c) $\breve{w}/\hat{w}$ *independent of* θ*.*

Proof Formal derivation and discussion in the text. ■

Intuitively, we find that the degree of openness has no effect on the conditions under which a poverty trap arises if the firm-performance measures (operating margins and revenue boosts/squeezes) do not depend on the openness and are the same across all markets, and if the magnitude of the mutual demand spillovers (captured by the wage ratio $\check{w}/\hat{w}$) does not depend on the world economy's openness to trade either.

4 A Global Economy with CES Preferences

As in Murphy et al. (1989), we adopt an upper-tier Cobb Douglas utility function $U\{x[\omega(z)]\} = \exp(\int_0^1 \ln u\{x[\omega(z)]\}dz)$, which at the sector level nests symmetric CES sub-utility functions $u\{x[\omega(z)]\} = \{\int_{\omega(z)\in\Omega(z)} x[\omega(z)]^{(\sigma-1)/\sigma} d\omega(z)\}^{\sigma/(\sigma-1)}$ with $\sigma > 1$ as the constant elasticity of substitution. (Domestic) households maximise utility:

$$\max_{x[\omega(z)]} \; U\{x[\omega(z)]\} = \exp\left(\frac{\sigma}{\sigma-1}\int_0^1 \ln\left\{\int_{\omega(z)\in\Omega(z)} x[\omega(z)]^{\frac{\sigma-1}{\sigma}} d\omega(z)\right\} dz\right), \tag{11}$$

subject to their budget constraint:

$$E = \int_0^1 \int_{\omega(z)\in\Omega(z)} p[\omega(z)]x[\omega(z)]d\omega(z)dz. \tag{12}$$

Demand for variety $\omega(z)$ in sector z therefore can be solved as:

$$x[\omega(z)] = p[\omega(z)]^{-\sigma}E, \tag{13}$$

in which:

$$P \equiv \left\{\int_0^1 \int_{\omega(z)\in\Omega(z)} p[\omega(z)]^{1-\sigma} d\omega(z)dz\right\}^{\frac{1}{1-\sigma}} \tag{14}$$

denotes the economy-wide ideal price index. In general equilibrium, we are free in the choice of a *numéraire*, and following Neary (2003, 2016) we choose marginal utility for this role, which implies that all prices are defined relative to the cost of marginal utility, which is given by λ^{-1}, the inverse of the marginal utility of income. With $\lambda^{-1} = 1$, prices then have the interpretation of *real prices at the margin*, and the same is true for the wage rate. Because the marginal utility of income λ is given by the price index P this normalization implies that $P = 1$.

Firm $\omega(z)$ in sector z can be of type $i \in \{T, M\}$ and maximizes its total profits:

$$\max_{p_i[\omega(z)],\, p^*_{in}[\omega(z)]} \{p_i[\omega(z)] - (v\delta)^{\mathbb{I}} w\} p_i[\omega(z)]^{-\sigma} E \\ + \sum_{n=1}^{N} \{p^*_{in}[\omega(z)] - \tau (v\delta)^{\mathbb{I}} w\} p^*_{in}[\omega(z)]^{-\sigma} E^* - \mathbb{I} \cdot vwF, \tag{15}$$

by choosing the optimal prices $p_i[\omega(z)]$ and $p^*_{in}[\omega(z)]$ at which it sells domestically and abroad. In Eq. (15) we have introduced the indicator variable $\mathbb{I} \in \{0, 1\}$, which takes a value of one if the firm uses the modern technology, i.e. $i = M$, and a value of zero if the firm uses the traditional technology, i.e. $i = T$.

Due to the additive separability of Eq. (15) it is straightforward to compute the optimal prices, quantities, revenues, and profits in Table 1. Constant mark-up pricing thereby implies

Table 1: *Firm-level Variables with CES Preferences*

	Domestic Market	**Foreign Markets**
Prices:	$p_i = \left(\frac{\sigma}{\sigma-1}\right)(v\delta)^{\mathbb{I}} w$	$p^*_i = \left(\frac{\sigma}{\sigma-1}\right)(v\delta)^{\mathbb{I}} \tau w$
Quantities:	$x_i = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(v\delta)^{-\mathbb{I}\sigma} w^{-\sigma} E$	$x^*_i = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(v\delta)^{-\mathbb{I}\sigma} \tau^{-\sigma} w^{-\sigma} E^*$
Revenues:	$r_i = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(v\delta)^{\mathbb{I}(1-\sigma)} w^{1-\sigma} E$	$r^*_i = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(v\delta)^{\mathbb{I}(1-\sigma)} \tau^{1-\sigma} w^{1-\sigma} E^*$
Op. Profits:	$\pi_i = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(v\delta)^{\mathbb{I}(1-\sigma)} w^{1-\sigma} E$	$\pi^*_i = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(v\delta)^{\mathbb{I}(1-\sigma)} \tau^{1-\sigma} w^{1-\sigma} E^*$

Notes: $\mathbb{I} = 1$ if $i = M$ and $\mathbb{I} = 0$ if $i = T$.

that the operating margin is constant and the same across all markets:

$$\mu_i = \mu^*_i = \frac{1}{\sigma} \in (0, 1) \;\; \forall \;\; i \in \{T, M\}. \tag{16}$$

Also, we can compute the revenue boost of unilateral modernization and the revenue squeeze resulting from unilateral non-modernization, respectively, as:

$$\hat{\eta} = (v\delta)^{1-\sigma} > 1, \quad \text{and} \quad \check{\eta} = (v\delta)^{\sigma-1} < 1. \tag{17}$$

In general equilibrium the wages $\hat{w}$ and $\check{w}$ can be solved from the respective labour market clearing conditions:

$$L = \hat{x}_T + N\tau\hat{x}^*_T \quad \text{and} \quad (1-f)L = \delta\left(\check{x}_M + N\tau\check{x}^*_M\right). \tag{18}$$

Because the operating margin is constant, we can link the firm-level wage bills for production workers to aggregate expenditure levels, i.e. $\hat{w}L = [(\sigma-1)/\sigma](\hat{r}_T + N\hat{r}^*_T) = [(\sigma-1)/\sigma]\widehat{E}$ and

$v\check{w}(1-f)L = [(\sigma-1)/\sigma](\check{r}_M + N\check{r}_M^*) = [(\sigma-1)/\sigma]\check{E}$. Using the above conditions to obtain outputs $\hat{x}_T$, $\hat{x}_T^*$, $\check{x}_M$ and $\check{x}_M^*$ that solely depend on $\hat{w}$ or $\check{w}$, we can solve for the wage levels $\hat{w}$ and $\check{w}$ by substituting $\hat{x}_T$, $\hat{x}_T^*$, $\check{x}_M$ and $\check{x}_M^*$ into the respective labour market clearing conditions from Eq. (18). The wage rates then can be solved as:

$$\hat{w} = \frac{\sigma-1}{\sigma}\theta^{\frac{1}{1-\sigma}} \qquad \text{and} \qquad \check{w} = \frac{1}{v\delta}\frac{\sigma-1}{\sigma}\theta^{\frac{1}{1-\sigma}}, \tag{19}$$

using the fact that the domestic expenditure share $\theta = \hat{\theta} = \check{\theta} = 1/(1+N\tau^{1-\sigma})$ only depends on parameters. Inspecting Eq. (19) reveals that – irrespective of the economy's openness – wages in an industrialised equilibrium are by factor $1/v\delta > 1$ larger than in a non-industrialised equilibrium:

$$\frac{\check{w}}{\hat{w}} = \frac{1}{v\delta} > 1. \tag{20}$$

Substituting the results from Eqs. (16), (17), and (20) into boundary conditions $\widehat{\Pi}_M = \widehat{\Pi}_T$, $\check{\Pi}_M = \check{\Pi}_T$, and $\check{\Pi}_M = \widehat{\Pi}_T$ finally allows us to rewrite these conditions as:[7]

$$\widehat{\Pi}_M = \widehat{\Pi}_T \iff \hat{f}(\delta) \equiv f = \frac{(v\delta)^{1-\sigma}-1}{v(\sigma-1)}, \tag{21}$$

$$\check{\Pi}_M = \check{\Pi}_T \iff \check{f}(\delta) \equiv f = \frac{(v\delta)^{1-\sigma}-1}{\sigma(v\delta)^{1-\sigma}-1}, \tag{22}$$

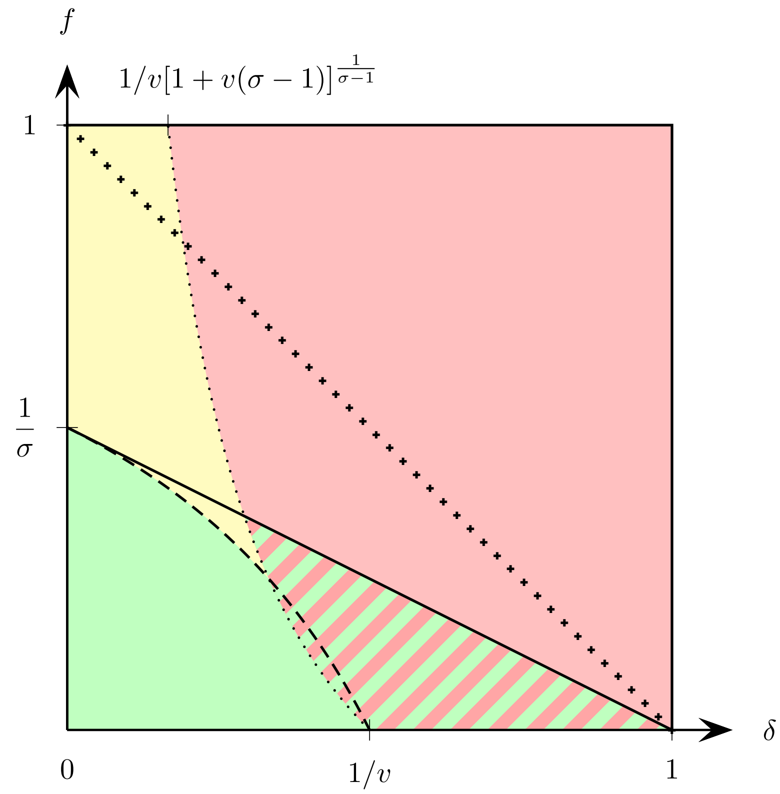
$$\check{\Pi}_M = \widehat{\Pi}_T \iff \bar{f}(\delta) \equiv f = \frac{1-\delta}{\sigma}. \tag{23}$$

In Figure 2 we plot the boundary conditions for the first firm to modernise $\widehat{\Pi}_M = \widehat{\Pi}_T$ (dotted curve) and the last firm to modernise $\check{\Pi}_M = \check{\Pi}_T$ (dashed curve) together with the boundary condition for a coordinated modernisation $\check{\Pi}_M = \widehat{\Pi}_T$ (solid line). We use the colors red (no industrialisation), yellow (incomplete industrialisation), and green (complete industrialisation) to identify parameter regions that support different equilibria types. Parameter combinations below the main diagonal of the box, given by the condition $f+\delta = 1$, are associated with Pareto improvements of modernization.

As in Murphy et al.'s (1989) Big Push model there exist parameter combinations (red/green parameter space) for which multiple equilibria, characterised by no versus complete industrialisation exist. Multiple equilibria arise because a coordinated transition to the modern technology across all sectors would be profitable for each firm, whereas the individual adoption of the modern technology by a single firm would result in a loss for this firm. The exogenous wage premium creates a pecuniary demand externality. Individual firms rationally ignore the demand spillovers that would emerge from the higher income of their workers, and therefore choose to underinvest

[7] The formal discussion of the boundary conditions in Eqs. (21) to (23) is delegated to Appendix A.1.

Figure 2: *The Big Push in a Global Economy with CES Preferences*



into technology upgrading.

Comparing Figures 1 and 2, two differences between the original Murphy et al. (1989) model and our extension stand out. First, in Murphy et al. (1989) a poverty trap can only arise in the presence of fixed costs of technology upgrading, i.e. for $f > 0$, whereas our model is also capable of generating a poverty trap for $f = 0$, provided that the reduction in marginal costs is not too large (specifically, $\delta > 1/v$ must hold for this outcome). The rationale for this result is that the fixed costs of technology adoption are not the only costs associated with modernisation. As first pointed out by Arrow (1962), there is a displacement effect associated with the adoption of the modern technology: In order to use the modern technology the firm has to give up the (non-zero) profits it earns by using its traditional technology. Due to these opportunity costs it is possible that the individual adoption of the modern technology is unprofitable although the fixed costs of adopting this technology are zero.

The second key aspect in which our model differs from Murphy et al.'s (1989) original work is the existence of an additional equilibrium type that is characterised by incomplete industrialisation (indicated by the yellow parameter space in Figure 2). In this parameter region modernisation only pays off if not all firms choose the option, and therefore the modern firms gain a competitive advantage over at least some of their rivals, with revenues, according to Eq. (17), that exceed those of their traditional competitors by the factor $(v\delta)^{\sigma-1} > 1$. This competitive advantage gives an incentive for individual firms to modernize even in some situations in which modernization is not Pareto optimal, as illustrated by the fact that parts of the yellow parameter space in Figure 2 lie above the main diagonal.

We summarise our discussion of Figure 2 in form of the following proposition.

Proposition 2 *With CES preferences our model features three different types of unique equilibria, which are characterised by:*

(a) no industrialisation,

(b) incomplete industrialisation,

(c) complete industrialisation,

as well as multiple equilibria, which are characterised by:

(d) no versus complete industrialisation.

Proof Delegated to Appendix A.2.

We conclude our discussion of the open-economy model with CES preferences by analysing how the boundary conditions in Figure 2 depend on the openness to trade, which is inversely related to the domestic expenditure share θ. Eqs. (16), (17), and (20) in combination with Corollary 1 suggest that none of the three boundary conditions depends on the domestic expenditure share (see also the Eqs. (21) to (23)). Therefore, in our model with CES preferences and monopolistic competition among a fixed number of firms the forces of globalisation have no effect on how easy or difficult it is to escape from a poverty trap. This result is remarkable given that international trade *per se* is good for consumers, whose welfare in a global economy is by factor $\theta^{1/(1-\sigma)} > 1$ larger than under autarky due to globalisation gains from "love of variety". To explain our neutrality result, it is important to understand that market size not welfare is relevant for the transition from a bad- to a good-technology equilibrium. Because firms' operating margins are constant and identical across all markets under CES preferences (cf. Mrázová and Neary, 2019), the reduction in domestic sales in response to import competition is exactly offset by the gain in foreign sales due to improved export opportunities. As a consequence, we find that international trade – although good for consumers – does not facilitate the escape from a poverty trap.

5 A Global Economy with Quadratic Preferences

We now analyze the possibility of a poverty trap in model with monopolistic competition and continuum quadratic preferences (cf. Melitz and Ottaviano, 2008), which yields the well-known implication that mark-ups are non-constant. To maintain tractability in this somewhat richer modeling environment, we are focusing in the following on a specific globalisation scenario, which compares the two boundary cases of autarky and free trade.

Upper-tier utility $U\{x[\omega(z)]\} = \int_0^1 u\{x[\omega(z)]\}dz$ is the sum over quadratic lower-tier utility:

$$u\{x[\omega(z)]\} = \alpha \int\limits_{\omega(z)\in\Omega(z)} x[\omega(z)]d\omega(z) - \frac{\gamma}{2} \int\limits_{\omega(z)\in\Omega(z)} x[\omega(z)]^2 d\omega(z) - \frac{\beta}{2}\Bigg\{\int\limits_{\omega(z)\in\Omega(z)} x[\omega(z)]d\omega(z)\Bigg\}^2, \quad \alpha, \beta, \gamma > 0, \tag{24}$$

with $\omega(z)$ as the identifier of a specific product variety in sector z. Without loss of generality we normalise $\alpha = \beta = 1$ but keep $\gamma \in (0, 1)$, which measures the degree of product differentiation. (Domestic) households maximize utility:

$$\max_{x[\omega(z)]} \; U\{x[\omega(z)]\} = \int_0^1 u\{x[\omega(z)]\}dz \quad \text{s.t.} \quad E = \int_0^1 \int_{\omega(z)\in\Omega(z)} p[\omega(z)]x[\omega(z)]d\omega(z)dz. \tag{25}$$

Demand for variety $\omega(z)$ in sector z therefore can be solved as:

$$x[\omega(z)] = \frac{1}{\gamma + 1 + N} - \frac{1}{\gamma} p[\omega(z)] + \frac{1}{\gamma}\frac{1 + N}{\gamma + 1 + N} P(z), \tag{26}$$

in which:

$$P(z) \equiv \frac{1}{1 + N} \int\limits_{\omega(z)\in\Omega(z)} p[\omega(z)]d\omega(z) \tag{27}$$

denotes the average price in sector z, and in which the inverse of the marginal utility of income:

$$\lambda = \frac{\gamma(1 + N)\int_0^1 P(z)dz - \gamma(\gamma + 1 + N)E}{(\gamma + 1 + N)\int_0^1 \int_{\omega(z)\in\Omega(z)} p[\omega(z)]^2 d\omega(z)dz + (1 + N)^2 P} \overset{!}{=} 1 \tag{28}$$

has been normalised to one due to our choice of marginal utility as *numéraire*. Note that the marginal utility of income λ contains only aggregate variables (such as total expenditure $E > 0$, average prices $P \equiv \int_0^1 P(z)dz > 0$, as well as the average of the second uncentered moments of the sectoral price distributions $\int_0^1 \int_{\omega(z)\in\Omega(z)} p[\omega(z)]^2 d\omega(z)dz$), and therefore may be interpreted as a sufficient statistic for how firms in each sector perceive the rest of the economy as a whole.

Firm $\omega(z)$ in sector z can be of type $i \in \{T, M\}$ and maximizes its total profits:

$$\max_{p_i[\omega(z)],\, p^*_{in}[\omega(z)]} \{p_i[\omega(z)] - (v\delta)^{\mathbb{I}} w\} \left\{ \frac{1}{\gamma+1+N} - \frac{1}{\gamma} p_i[\omega(z)] + \frac{1}{\gamma}\frac{1+N}{\gamma+1+N} P(z) \right\}$$
$$+ \sum_{n=1}^{N} \{p^*_{in}[\omega(z)] - (v\delta)^{\mathbb{I}} w\} \left\{ \frac{1}{\gamma+1+N} - \frac{1}{\gamma} p^*_{in}[\omega(z)] + \frac{1}{\gamma}\frac{1+N}{\gamma+1+N} P^*_n(z) \right\} - \mathbb{I} v w F, \tag{29}$$

by choosing the optimal prices $p_i[\omega(z)]$ and $p^*_{in}[\omega(z)]$ at which it sells domestically and abroad. As in Eq. (15), the technology indicator $\mathbb{I} \in \{0, 1\}$ takes a value of one if the firm uses the modern technology, i.e. $i = M$, and a value of zero if the firm uses the traditional technology, i.e. $i = T$. In order to solve the corresponding first order conditions:

$$p_i[\omega(z)] \overset{!}{=} \frac{1}{2}\frac{\gamma}{\gamma+1+N} + \frac{1}{2}\frac{1+N}{\gamma+1+N} P(z) + \frac{1}{2}(v\delta)^{\mathbb{I}} w, \tag{30}$$

$$p^*_{in}[\omega(z)] \overset{!}{=} \frac{1}{2}\frac{\gamma}{\gamma+1+N} + \frac{1}{2}\frac{1+N}{\gamma+1+N} P^*_n(z) + \frac{1}{2}(v\delta)^{\mathbb{I}} w, \tag{31}$$

for $p_i[\omega(z)]$ and $p^*_{in}[\omega(z)]$, respectively, we have to specify the firms' competitive environment, distinguishing between a situation in which all competitors use the traditional technology, with sectoral price indices $\widehat{P}(z)$ and $\widehat{P}^*(z)$, and a situation in which all competitors use the modern technology, with sectoral price indices $\breve{P}(z)$ and $\breve{P}^*(z)$. Firms are massless and their marginal effect on the sectoral price index $P(z)$ is negligible. Symmetry therefore implies that the sectoral price indices are given by:

$$\widehat{P}(z) = \widehat{P}^*(z) = \frac{1}{1+N}\hat{p}_T + \frac{N}{1+N}\hat{p}^*_T, \tag{32}$$

$$\breve{P}(z) = \breve{P}^*(z) = \frac{1}{1+N}\breve{p}_M + \frac{N}{1+N}\breve{p}^*_M. \tag{33}$$

Substituting $\hat{p}_T$, $\hat{p}^*_T$, $\breve{p}_M$ and $\breve{p}^*_M$ from the first order conditions in Eqs. (30) and (31) into the sectoral price indices in Eqs. (32) and (33) then allows us to solve for these as:

$$\widehat{P}(z) = \widehat{P}^*(z) = \frac{\gamma}{2\gamma+1+N}\left[1 + \frac{\gamma+1+N}{\gamma}\left(\frac{1}{1+N} + \frac{N}{1+N}\right)\hat{w}\right], \tag{34}$$

$$\breve{P}(z) = \breve{P}^*(z) = \frac{\gamma}{2\gamma+1+N}\left[1 + \frac{\gamma+1+N}{\gamma}\left(\frac{1}{1+N} + \frac{N}{1+N}\right)v\delta\breve{w}\right]. \tag{35}$$

With the sectoral price indices in Eqs. (34) and (35) at hand, we are now equipped to compute the optimal prices, quantities, revenues, and profits in Table 2.

Table 2: *Firm-level Variables with Quadratic Preferences*

	Domestic Market	
Prices:	$\hat{p}_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}{2(2\gamma+1+N)} + (v\delta)^{\mathbb{I}}\hat{w}$	$\check{p}_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}{2(2\gamma+1+N)} + (v\delta)^{\mathbb{I}}\check{w}$
Quantities:	$\hat{x}_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}{2\gamma(2\gamma+1+N)}$	$\check{x}_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}{2\gamma(2\gamma+1+N)}$
Revenues:	$\hat{r}_i = \frac{2\gamma[1+(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1+(v\delta)^{\mathbb{I}}]\hat{w}}{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}\hat{\pi}_i$	$\check{r}_i = \frac{2\gamma[1+(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)+(v\delta)^{\mathbb{I}}]\check{w}}{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}\check{\pi}_i$
Op. Profits:	$\hat{\pi}_i = \frac{1}{\gamma}\frac{\{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}\}^2}{4(2\gamma+1+N)^2}$	$\check{\pi}_i = \frac{1}{\gamma}\frac{\{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}\}^2}{4(2\gamma+1+N)^2}$
	Foreign Markets	
Prices:	$\hat{p}^*_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}{2(2\gamma+1+N)} + (v\delta)^{\mathbb{I}}\hat{w}$	$\check{p}^*_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}{2(2\gamma+1+N)} + (v\delta)^{\mathbb{I}}\check{w}$
Quantities:	$\hat{x}^*_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}{2\gamma(2\gamma+1+N)}$	$\check{x}^*_i = \frac{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}{2\gamma(2\gamma+1+N)}$
Revenues:	$\hat{r}^*_i = \frac{2\gamma[1+(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1+(v\delta)^{\mathbb{I}}]\hat{w}}{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}\hat{\pi}^*_i$	$\check{r}^*_i = \frac{2\gamma[1+(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)+(v\delta)^{\mathbb{I}}]\check{w}}{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}}\check{\pi}^*_i$
Op. Profits:	$\hat{\pi}^*_i = \frac{1}{\gamma}\frac{\{2\gamma[1-(v\delta)^{\mathbb{I}}\hat{w}]+(1+N)[1-(v\delta)^{\mathbb{I}}]\hat{w}}{4(2\gamma+1+N)^2}$	$\check{\pi}^*_i = \frac{1}{\gamma}\frac{\{2\gamma[1-(v\delta)^{\mathbb{I}}\check{w}]+(1+N)[(v\delta)-(v\delta)^{\mathbb{I}}]\check{w}\}^2}{4(2\gamma+1+N)^2}$

Notes: $\mathbb{I}=1$ if $i=M$ and $\mathbb{I}=0$ if $i=T$.

In general equilibrium we can solve for the wage rates $\hat{w}$ and $\check{w}$ as:

$$\hat{w} = \frac{2\gamma[(1+N)-(2\gamma+1+N)L]}{2\gamma(1+N)}, \tag{36}$$

$$\check{w} = \frac{2\gamma[(1+N)-(2\gamma+1+N)L(1-f)/\delta]}{2\gamma(1+N)}\frac{1}{v\delta}, \tag{37}$$

by substituting the quantities $\hat{x}_T$, $\hat{x}^*_T$, $\check{x}_M$ and $\check{x}^*_M$ from Table 2 into the respective labour market clearing conditions from Eq. (18).

In order to express the boundary conditions $\widehat{\Pi}_M = \widehat{\Pi}_T$, $\check{\Pi}_M = \check{\Pi}_T$, and $\widehat{\Pi}_M = \check{\Pi}_T$ as functions of the model's fundamental parameters, we substitute $\hat{\pi}_i$, $\check{\pi}_i$, $\hat{\pi}^*_i$ and $\check{\pi}^*_i$ from Table 2 together with $\hat{w}$ and $\check{w}$ from Eqs. (36) and (37) into $\Pi_T \equiv \pi_T + N\pi^*_T$ and $\Pi_M \equiv \pi_M + N\pi^*_M - vwfL$. The above boundary conditions can then be expressed as implicit functions $\hat{f}(\delta) = f$, $\bar{f}(\delta) = f$, and $\check{f}(\delta) = f$ with:

$$\hat{f}(\delta) \equiv \frac{(1-v\delta)\{[2\gamma-(1+N)+(2\gamma+1+N)v\delta]L+(1+N)(1-v\delta)\}}{4\gamma vL}, \tag{38}$$

$$\check{f}(\delta) \equiv \frac{(1-v\delta)[\{2\gamma+1+N+[2\gamma-(1+N)]v\delta\}L-(1+N)\delta(1-v\delta)]}{\{(2\gamma+1+N)[1+(v\delta)^2]-2(1+N)v\delta\}L}, \tag{39}$$

$$\bar{f}(\delta) \equiv \frac{(L-\delta)(1+N)+\sqrt{\delta(\delta-2L)(1+N)^2+L^2[(2\gamma+1+N)^2-4\gamma(\gamma+1+N)\delta^2]}}{2(\gamma+1+N)L}, \tag{40}$$

which not only depend on δ but also on v, γ, and N.[8]

We furthermore restrict the admissible parameter space to ensure labour market clearing at positive wages, i.e. $\min\{\hat{w}, \check{w}\} > 0$, by imposing the additional constraint:

$$f > g(\delta) \equiv 1 - \frac{1+N}{2\gamma+1+N}\frac{\delta}{L}, \tag{41}$$

for $(1-f)/\delta > 1$.[9]

In Figure 3 we plot the boundary conditions for the first firm to modernise $\widehat{\Pi}_M = \widehat{\Pi}_T$ (dotted curve) and the last firm to modernise $\check{\Pi}_M = \check{\Pi}_T$ (dashed curve) together with the boundary condition for a coordinated modernisation $\check{\Pi}_M = \widehat{\Pi}_T$ (solid line). Parameter combinations below the main diagonal of the box, given by the condition $f + \delta = 1$, are again associated with Pareto improvements of modernization. We use the colors red (no industrialisation), yellow (incomplete industrialisation), and green (complete industrialisation) to identify parameter regions that support different equilibria types. We restrict our attention to the non-grey coloured parameter space in Figure 3 to ensure that the full-employment condition $f > g(\delta)$ in Eq. (41) is not violated.[10]

Confining attention to parameter combinations that lie outside the grey area, Figures 2 and 3 share the same basic structure with a (red/green) parameter space that allows for a multiplicity of equilibria in the open economy. Multiple equilibria arise for the same reason as in Murphy et al. (1989): The exogenous wage premium raises the firms' costs and renders individual technology adoption unprofitable. However, if sufficiently many firms adopt the modern technology, the higher income of their workers creates an extra demand, that allows firms across all industries to break even when adopting the modern technology.

We summarise our discussion of Figure 3 in the following proposition.

Proposition 3 *With continuum-quadratic preferences our model features three different types of unique equilibria, which are characterised by:*

(a) no industrialisation,

[8]The formal discussion of the boundary conditions in Eqs. (38) to (40) is delegated to Appendix A.3.

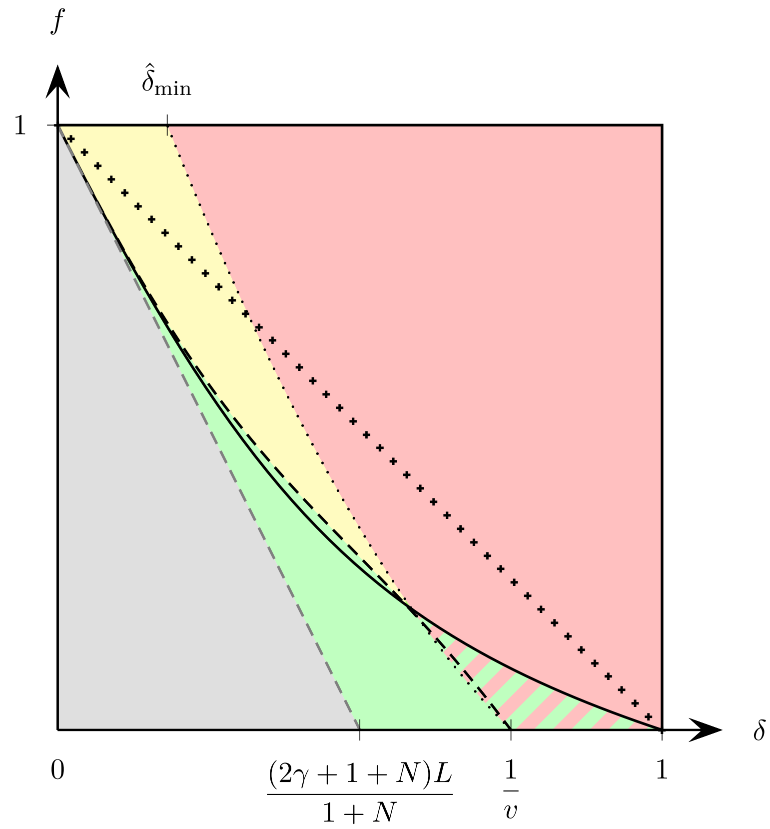
[9]Note that the condition in Eq. (41) is violated for sufficiently low values of f and δ. For a sufficiently high labour productivity $1/\delta$ and a sufficiently low fixed labour requirement f (modernized) firms can produce consumers' saturation quantity without exhausting the economy's total labour supply. To avoid an equilibrium outcome with zero wages and involuntary unemployment we hence assume Eq. (41) to hold.

[10]Note that parameter regions, which support unique equilibria with complete and incomplete industrialisation (green- and yellow-coloured areas), may completely overlap with the non-admissible parameter space (grey-coloured area) in Figure 3 if the exogenous wage premium $v > 1$ is sufficiently large and that:

$$v < \min\left\{\frac{1+N}{2\gamma+1+N}, \frac{1}{2} + \frac{1+N}{4\gamma}(1-L)\right\}\frac{1}{L}$$

is required to ensure that there is no complete overlap.

Figure 3: *The Big Push with Quadratic Preferences (Autarky vs. Free Trade)*



(b) incomplete industrialisation,

(c) complete industrialisation,

as well as multiple equilibria, which are characterised by:

(d) no versus complete industrialisation.

Proof Delegated to Appendix A.4.

Having established the existence of a poverty trap in the open economy, we can now address the question under which regime (autarky versus free trade) it is easier to escape from the vicious cycle of poverty. For this purpose, we focus on the boundary condition $\breve{\Pi}_M - \widehat{\Pi}_T = 0$ (solid curve) for a coordinated adoption of the modern technology and show in Appendix A.5 that a transition from autarky (i.e. $N = 0$) to free trade (i.e. $N > 0$) has a negative impact on the corresponding function $\bar{f}(\delta)$, which continues to have the same intercepts but otherwise is shifted to the origin of Figure 3. To understand the impact of globalisation it is instructive to recall the general definition of the profit difference $\breve{\Pi}_M - \widehat{\Pi}_T$ in Eq. (8), which only depends on the operating margins $\breve{\mu}_M$, $\breve{\mu}^*_M$, $\hat{\mu}_T$, $\hat{\mu}^*_T$ and on the relative wage rate $\breve{w}/\hat{w}$. With the results from Table 2 and the wage rates $\hat{w}$ and $\check{w}$ from Eqs. (36) and (37) at hand, it is easily verified that:

$$\hat{\mu}_T = \hat{\mu}_T^* = \frac{\gamma(1-\hat{w})}{\gamma(1+\hat{w}) + (1+N)\hat{w}} \quad \text{and} \quad \check{\mu}_M = \check{\mu}_M^* = \frac{\gamma[1-(v\delta)\check{w}]}{\gamma[1+(v\delta)\check{w}] + (1+N)(v\delta)\check{w}}. \tag{42}$$

An increasing number of trading partners N has a pro-competitive effect that according to Eq. (42) directly lowers the operating margins.[11] Increasing N moreover has an indirect general equilibrium effect that operates through the effect on the relative wage rate $\check{w}/\hat{w}$. From Eqs. (36) and (37), we can compute:

$$\frac{\check{w}}{\hat{w}} = \frac{(1+N) - (2\gamma+1+N)L(1-f)/\delta}{(1+N) - (2\gamma+1+N)L} \frac{1}{v\delta}. \tag{43}$$

Industrialisation raises wages by a factor that is smaller than $1/v\delta > 1$ since $\delta < 1-f$.[12] The reason for this less than proportional increase is that firms do not pass through all the cost savings from adopting the modern technology to their consumers. By collectively adopting the modern technology, the economy's production possibilities expand by factor $(1-f)/\delta > 1$. Each firm therefore produces more output and moves down its linear demand curve into an area where demand is less elastic. The associated increase in market power allows firms to capture a larger share of aggregate income and leaves a smaller share of aggregate income for (production) workers, which therefore experience a less than proportional increase in their wages. In the open economy this shift in income shares is less pronounced because firms sell lower quantities in each market and therefore have less market power to begin with. As a consequence we find that the relative wages $\check{w}/\hat{w}$ in Eq. (43) are increasing in the number of trading partners N. In summary, we can conclude that an increase in N not only is responsible for a reduction in firms' market power and the operating margins $\check{\mu}_M$, $\check{\mu}_M^*$, $\hat{\mu}_T$, $\hat{\mu}_T^*$, but also for an increase in the (fixed) costs of technology upgrading, reflected by an increase in the wage ratio $\check{w}/\hat{w}$. Both effects render a coordinated adoption of the modern technology less attractive, which is why the function $\bar{f}(\delta)$ (solid curve) is shifted to the origin of Figure 3.

6 Conclusion

In this paper we incorporate Murphy et al.'s (1989) famous Big Push model into a multi-country international trade model with a given number of monopolistically competitive firms. We show

[11] Note that the direct pro-competitive effect that an increase in the number of trading partners N has on the operating margins is reinforced in general equilibrium because the wages $\hat{w}$ and $\check{w}$ in Eq. (42) also increase in N (see Eqs. (36) and (37)).

[12] According to Eq. (41) the numerator and the denominator of Eq. (43) are both positive.

that poverty traps are a possible feature of a global economy with international trade, and we analyze the channels through which international trade affects the likelihood for a country to escape from a poverty trap. With an iso-elastic demand system, as it is typically derived from CES preferences, globalisation has no effect on market shares, operating margins and the wage-increasing effect of industrialisation, which is why firm's inclination to adopt a modern increasing-returns-to-scale technology as the replacement of a traditional constant-returns-to-scale technology does not depend on the degree of trade integration. By contrast, under continuum quadratic preferences, which imply a linear demand system, the conditions for a poverty trap to arise are no longer the same under autarky and free trade. Moving from autarky to free trade is associated with a pro-competitive effect due to the entry of foreign competitors, which renders the coordinated adoption of the increasing-returns-to-scale technology (Big Push) more difficult.

Because we have focused on an environment in which the gains from trade arise due to love of variety at the demand side, international trade – although generally welfare-enhancing – not necessarily facilitate the transition from a bad- to a good-technology equilibrium. While beyond the scope of this paper, we expect that in models where the gains from trade are associated with an efficiency-enhancing resource reallocation between industries (cf. Eaton and Kortum, 2002) and/or firms (cf. Melitz, 2003), the coordinated adoption of an increasing-returns-to-scale technology (Big Push) gets facilitated through the expansion of high-productivity industries or firms and the shutdown of low-productivity industries or firms.

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A Appendix

A.1 Formal Discussion of the Boundary Conditions in Eqs. (21) to (23)

The relevant domain of $\hat{f}(\delta)$ is given by $\delta \in [\hat{\delta}_{\min}, \hat{\delta}_{\max}]$ with $\hat{\delta}_{\min} \equiv 1/v[1+v(\sigma-1)]^{1/(\sigma-1)} \in (0,1)$ and $\hat{\delta}_{\max} \equiv 1/v \in (0,1)$. Evaluating $\hat{f}(\delta)$ at $\hat{\delta}_{\min}$ and $\hat{\delta}_{\max}$ results in $\hat{f}(\hat{\delta}_{\min}) = 1$ and $\hat{f}(\hat{\delta}_{\max}) = 0$. The boundary condition $\hat{f}(\delta)$ is a convexly declining function in $\delta \in [\hat{\delta}_{\min}, \hat{\delta}_{\max}]$ because $\hat{f}'(\delta) = -(v\delta)^{-\sigma} < 0 < \hat{f}''(\delta) = \sigma v (v\delta)^{-(\sigma+1)}$.

The relevant domain of $\check{f}(\delta)$ is given by $\delta \in [\check{\delta}_{\min}, \check{\delta}_{\max}]$ with $\check{\delta}_{\min} \equiv 0$ and $\check{\delta}_{\max} \equiv 1/v \in (0,1)$. Evaluating $\check{f}(\delta)$ at $\check{\delta}_{\min}$ and $\check{\delta}_{\max}$ results in $\check{f}(\check{\delta}_{\min}) = 1/\sigma$ and $\check{f}(\check{\delta}_{\max}) = 0$. The slope and curvature of boundary condition $\check{f}(\delta)$ can be computed as:

$$\check{f}'(\delta) = -\frac{(\sigma-1)^2 v (v\delta)^{-\sigma}}{[\sigma(v\delta)^{1-\sigma} - 1]^2} < 0 \quad \text{and} \quad \check{f}''(\delta) = -\check{f}'(\delta)\frac{\sigma v (v\delta)^{-1}[(2-\sigma)(v\delta)^{1-\sigma} - 1]}{[\sigma(v\delta)^{1-\sigma} - 1]}. \tag{A.1}$$

By inspection of Eq. (A.1) it follows that $\check{f}(\delta)$ is a concavely decreasing function in δ for $\sigma \geq 2$. For $\sigma < 2$ the second derivative $\check{f}''(\delta)$ is positive for low values of δ and negative for high values of δ with a unique inflection point at $(2-\sigma)^{1/(\sigma-1)}/v \in [\check{\delta}_{\min}, \check{\delta}_{\max}]$.

The relevant domain of $\bar{f}(\delta)$ is given by $\delta \in [\bar{\delta}_{\min}, \bar{\delta}_{\max}]$ with $\bar{\delta}_{\min} \equiv 0$ and $\bar{\delta}_{\max} \equiv 1$. Evaluating boundary condition $\bar{f}(\delta)$ at $\bar{\delta}_{\min}$ and $\bar{\delta}_{\max}$ results in $\bar{f}(\bar{\delta}_{\min}) = 1/\sigma$ and $\bar{f}(\bar{\delta}_{\max}) = 0$. The boundary condition $\bar{f}(\delta)$ declines linearly in δ. ■

A.2 Proof of Proposition 2

We have $\check{\delta}_{\min} = \bar{\delta}_{\min} = 0 < \hat{\delta}_{\min} < 1/v[1+v(\sigma-1)]^{1/(\sigma-1)} < 1$ and $\hat{\delta}_{\max} = \check{\delta}_{\max} = 1/v < \bar{\delta}_{\max} = 1$. Evaluating the boundary conditions in Eqs. (21) to (23) at $\hat{\delta}_{\min}$, $\check{\delta}_{\min}$, and $\bar{\delta}_{\min}$ as well as at $\hat{\delta}_{\max}$, $\check{\delta}_{\max}$, and $\bar{\delta}_{\max}$ results in $\check{f}(\check{\delta}_{\min}) = \bar{f}(\bar{\delta}_{\min}) = 1/\sigma < \hat{f}(\hat{\delta}_{\min}) = 1$ and $\hat{f}(\hat{\delta}_{\max}) = \check{f}(\check{\delta}_{\max}) = \bar{f}(\bar{\delta}_{\max}) = 0$. As a consequence, there exist parameter combinations, which support $\widehat{\Pi}_M < \widehat{\Pi}_T$ and $\widecheck{\Pi}_M > \widehat{\Pi}_T$.

We also have $\check{f}'(\check{\delta}_{\max}) = -v < \hat{f}'(\hat{\delta}_{\max}) = -1$, such that $\hat{f}(\delta)$ and $\check{f}(\delta)$ have unique intersection point at $\delta_0 \equiv \{[1+v(\sigma-1)]/\sigma]\}^{1/(1-\sigma)}/v \in (0,1)$. Moreover, the convexity of $\hat{f}(\delta)$ ensures that $\hat{f}(\delta)$ also intersects $\bar{f}(\delta)$. In order to show, that the intersection point between $\hat{f}(\delta)$ and $\bar{f}(\delta)$ lies to the northwest of the intersection point between $\hat{f}(\delta)$ and $\check{f}(\delta)$ we evaluate $\bar{f}(\delta)$ and $\check{f}(\delta)$ at δ_0 and show that:

$$\bar{f}(\delta_0) = \frac{1}{\sigma} - \frac{1}{\{[1+v(\sigma-1)]/\sigma]\}^{1/(\sigma-1)} v\sigma} > \frac{v-1}{v}\frac{1}{\sigma} = \check{f}(\delta_0), \tag{A.2}$$

if $v > 1$. Since $\bar{f}(\delta) > \check{f}(\delta)$ for all $\delta \in (0, 1/v)$ if $\sigma \leq 2$, there is no intersection point between

$\bar{f}(\delta)$ and $\check{f}(\delta)$ if $\sigma \leq 2$. For $\sigma > 2$ we repeatedly make use of L'Hôpital's rule in order to compute:

$$\lim_{\delta \to 0} \check{f}(\delta) = \lim_{\delta \to 0} -\frac{v}{2\sigma}(v\delta)^{\sigma-1} = 0, \tag{A.3}$$

which implies that there exists a unique intersection point between $\bar{f}(\delta)$ and $\check{f}(\delta)$ given that $\check{f}(\delta)$ is strictly convex for $\sigma \geq 2$. Due to the strict convexity of $\check{f}(\delta)$ it follows that the intersection point between $\bar{f}(\delta)$ and $\check{f}(\delta)$ lies to the northwest of the intersection point between $\hat{f}(\delta)$ and $\bar{f}(\delta)$. ■

A.3 Formal Discussion of the Boundary Conditions in Eqs. (38) to (40)

The relevant domain of $\hat{f}(\delta)$ is given by $\delta \in [\hat{\delta}_{\min}, \hat{\delta}_{\max}]$ with:

$$\hat{\delta}_{\min} \equiv \max\left\{0, \frac{(1+N)(1-L) - 2\sqrt{[(1+N)(1-L)v + (2v-1)\gamma L]\gamma L}}{[(1+N)(1-L) - 2\gamma L]v}\right\}, \tag{A.4}$$

and $\hat{\delta}_{\max} \equiv 1/v \in (0,1)$. Evaluating $\hat{f}(\delta)$ at $\hat{\delta}_{\min}$ and $\hat{\delta}_{\max}$ results in $\hat{f}(\hat{\delta}_{\min}) = 1$ if $\hat{\delta}_{\min} > 0$, $\hat{f}(\hat{\delta}_{\min}) = [1 + N - (1 + N - 2\gamma)L]/4v\gamma L < 1$, and $\hat{f}(\hat{\delta}_{\max}) = 0$. The boundary condition $\hat{f}(\delta)$ is a convexly declining function in $\delta \in [\hat{\delta}_{\min}, \hat{\delta}_{\max}]$ because $\hat{f}'(\delta) < 0 < \hat{f}''(\delta)$.

The relevant domain of $\check{f}(\delta)$ is given by $\delta \in [\check{\delta}_{\min}, \check{\delta}_{\max}]$ with $\check{\delta}_{\min} \equiv 0$ and $\check{\delta}_{\max} \equiv 1/v \in (0,1)$. Evaluating $\check{f}(\delta)$ at $\check{\delta}_{\min}$ and $\check{\delta}_{\max}$ results in $\check{f}(\check{\delta}_{\min}) = 1/\sigma$ and $\check{f}(\check{\delta}_{\max}) = 0$. We have $\check{f}'(0) < 0$ and $\check{f}'(1/v) < 0$ as well as $\check{f}'(1/v) < \hat{f}'(1/v)$ for $v > 1$ and $\check{f}'(1/v) = \hat{f}'(1/v)$ for $v = 1$.

The relevant domain of $\bar{f}(\delta)$ is given by $\delta \in [\bar{\delta}_{\min}, \bar{\delta}_{\max}]$ with $\bar{\delta}_{\min} \equiv 0$ and $\bar{\delta}_{\max} \equiv 1$. Evaluating boundary condition $\bar{f}(\delta)$ at $\bar{\delta}_{\min}$ and $\bar{\delta}_{\max}$ results in $\bar{f}(\bar{\delta}_{\min}) = 1$ and $\bar{f}(\bar{\delta}_{\max}) = 0$. The boundary condition $\bar{f}(\delta)$ declines convexly in $\delta \in [0,1]$ because of $\bar{f}'(\delta) < 0 < \bar{f}''(\delta)$. ■

A.4 Proof of Proposition 3

We have $\hat{\delta}_{\max} = \check{\delta}_{\max} = 1/v < \bar{\delta}_{\max} = 1$. Evaluating the boundary conditions in Eqs. (38) to (40) at $\hat{\delta}_{\max}$, $\check{\delta}_{\max}$, and $\bar{\delta}_{\max}$ results in $\hat{f}(\hat{\delta}_{\max}) = \check{f}(\check{\delta}_{\max}) = \bar{f}(\bar{\delta}_{\max}) = 0$. As a consequence, there exist parameter combinations, which support $\widehat{\Pi}_M - \widehat{\Pi}_T < 0$ and $\widecheck{\Pi}_M - \widehat{\Pi}_T > 0$. ■

A.5 The Effect of Globalization on the Boundary Condition $\widecheck{\Pi}_M = \widehat{\Pi}_T$

Note that we can rewrite the boundary condition $\widecheck{\Pi}_M - \widehat{\Pi}_T$ as:

$$\bar{f}(\delta, \widetilde{N}, L) = \frac{\widetilde{N}(L-\delta) + \sqrt{\delta(\delta - 2L)\widetilde{N}^2 + L^2[(2+\widetilde{N})^2 - 4(1+\widetilde{N})\delta^2]}}{2(1+\widetilde{N})L},$$

for which it can be demonstrated that $\partial \bar{f}(\delta, \widetilde{N}, L)/\partial \widetilde{N} < 0$ with $\widetilde{N} \equiv (1+N)/\gamma$. We moreover have $\bar{f}(0, \widetilde{N}, L) = 1$ and $\bar{f}(1, \widetilde{N}, L) = 0$. ■