Structural Change, Increasing Returns, and Growth of Trade

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Abstract

This paper links growth of trade to structural transformation in the major economies over the last several decades which have seen steadily declining manufacturing employment. The theoretical finding is that, under increasing returns, falling employment in manufacturing amplifies comparative advantage forces relative to trade barriers, specialization deepens to offset losses in scale in the marginal industries, and trade increases. I establish this result in a model based on Dornbusch, Fischer, and Samuelson (1977) to which I add exogenously nontraded services and fixed costs in manufacturing. Structural change tightens specialization pattern, inducing reallocation of resources towards industries with stronger comparative advantage. This suggests a new channel behind significant extensive margin movements in the data which the previous studies could not fully attribute to tariff reductions. As a consequence of structural transformation, trade becomes a larger fraction of manufacturing output and consumption for the same level of trade costs. This pattern contributes to explaining the observed puzzling growth in the trade-to-GDP ratio.

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1 Introduction

Since Krugman (1995), the declining GDP share of manufacturing output has been cited as slowing trade-to-GDP growth and thus exacerbating the trade growth puzzle. A common way to formulate this puzzle, e.g. Yi (2003), is that explaining the observed growth in the trade-to-GDP ratio with falling trade barriers implies implausibly high elasticity of substitution between domestic and imported goods.[1] As soon as international trade is mainly in manufactures, the decreasing manufacturing-to-GDP ratio (caused by slower productivity growth in services and/or by nonhomethetic preferences) reduces trade relative to GDP. This paper suggests that there is a force counteracting this effect. Falling manufacturing employment associated with structural transformation in the major economies over the last 30-40 years, combined with increasing returns and comparative advantage, can boost trade relative to manufacturing output for the same level of trade costs.

Intuitively, as labor moves away from manufacturing while demand for manufacturing goods is still growing, there becomes "more need for trade". More specifically, the role of comparative advantage rises relative to transportation costs, and more opportunities for specialization should be exploited. This happens precisely because of increasing returns: Specialization deepens to compensate for losses in scale in the marginal industries.

To formalize this argument, I develop a stylized model of structural change based on Dornbusch, Fischer, and Samuelson (1977) (DFS) to which I add exogenously non-traded services and fixed costs in manufacturing industries. Specialization is governed by the usual balance between comparative advantage and trade costs, but now additional resources are required to launch manufacturing products in both countries. This new modified trade-off resolves differently depending on the stage of structural transformation, which is in the heart of the paper. Under complementarity in consumption between services and manufactured goods, faster productivity growth in manufacturing generates endogenous structural change. The resulting decline in manufacturing employment makes it optimal to narrow specialization to save on fixed costs. The range of endogenously non-traded manufactures shrinks, and the countries trade more.

Introducing fixed costs dictates a departure from competitive environment, but first, to understand the general nature of the underlying forces independently of specific market structure assumptions, I study the planner's allocation in this economy. Another virtue

[1] Vertical specialization in Yi (2003) allows tariff reduction to account for about a half of trade growth. Overall, skepticism remains about the extent to which falling tariffs explain the recent growth of trade, in particular, by broadening the range of traded goods. Thus, Debaere and Mostashari (2010) find that only from 5% to 12% of the increasing extensive margin of trade is due to tariff reductions.

of the planner's problem is its high tractability. In the standard DFS setup, under additional assumption of symmetric countries,[2] specialization (set to minimize the cost of living) is solely pinned down by efficiency distribution and trade costs. This is no longer the case in a model with fixed costs and imperfect competition, where specialization is determined by market clearing in a way that involves interaction between general equilibrium conditions and profits in the marginal industries. Abstracting from markups greatly simplifies the solution, making the key model's trade-off very intuitive to demonstrate. The optimal specialization pattern maximizes welfare expressed as the ratio of resources left after paying fixed costs to the cost of living index. The incentive to save on fixed costs immediately narrows specialization relative to DFS; structural change moves it further towards the maximum level corresponding to zero trade costs.

Despite lower tractability, analyzing a corresponding decentralized model with imperfect competition is also straightforward. On top of exactly the same fundamentals as in the planner's problem, I consider oligopolistic market structure where each industry in each country has one potential producer of a good who serve internationally segmented markets competing a la Bertrand.[3] If, however, a (less efficient) firm cannot cover the fixed costs, it does not enter leaving both markets to its foreign competitor who is then a monopolist. In general equilibrium, provided that the range of nontraded goods is nondegenerate, to enter is a dominant strategy for the more efficient firm, by which the model avoids typical complications with multiple equilibria. The marginal firm that decides to enter enjoys effective (adjusted for trade costs that its foreign competitor needs to pay) efficiency advantage just enough to cover the fixed costs. By a general equilibrium effect on wages and sectoral price indexes, structural change tilts the mapping from cost advantage to profitability, such that the marginal firm's markup becomes insufficient to stay in business. Importantly, this effect only operates in economy with nontradable sector absorbing an increasing expenditure share. The precise reason behind that "tilted mapping" is that manufacturing demand rises less than one-for-one with manufacturing productivity because of intersectoral reallocation.

Bertrand competition decentralizes the planner's allocation not perfectly, but the general pattern of comparative statics holds. Structural transformation forces the weakest

[2] I assume throughout the paper that countries are similar in all characteristics, including population size and absolute advantage, while comparative advantage in tradables takes the form of labor requirements which are mirror images of each other.

[3] The model builds on a simplified version of Bernard, Eaton, Jensen, and Kortum (2003). Appendix A.3 solves a similar model under Cournot competition. It gives rise to a richer industry structure which can be of independent interest but is less central to the main argument of this paper.

comparative advantage industries to shut down, the range of endogenously nontraded goods shrinks, and trade becomes a larger share of manufacturing output for the same level of trade costs. Therefore, structural change provides a new source of extensive margin movements. With oligopolistic market structure, each entering firm pays fixed costs that are non-negligible relative to the industry size. The role of this industry-level lumpiness of fixed costs is crucial to activate the extensive margin. In contrast, assuming away discreteness of firms, monopolistic competition framework allows for infinitesimally small industry sizes, so the countries need not adjust on the extensive margin industry-wide.[4]

This theory is falsifiable by certain evidence on industry concentration and size distribution of firms in manufacturing. If fixed costs (capturing in the model such expenses as managerial effort and product development) do not play a role in determining specialization,[5] we would observe industries with smaller and smaller firms. As declining employment in manufacturing makes the increasing returns to scale motive more pronounced, the model predicts a thinner left tail of the firm size distribution in tradables. An obvious problem with using this prediction as a test is its consistence with the traditional reason for trade growth, that is falling costs of trade. The empirical studies do find that globalization is correlated with elimination of small firms, e.g. Gu, Sawchuk, and Rennison (2003) for the case of Canada, but this is interpreted as confirming the standard trade theories, like Melitz (2003).

What may differentiate between trade liberalization and structural change is the model's implication for markups. The endogenous market structure in manufacturing responds to intersectoral reallocation towards services with unambiguously growing monopolization, which translates into weakly increasing markups. (Markups stay constant if high trade costs do not restrict pricing of the marginal firms in domestic markets.) This is in contrast to the common view of pro-competitive effects of trade (e.g. Melitz and Ottaviano (2008)), but in line with several recent studies that challenge it (Arkolakis, Costinot, Donaldson, and Rodriguez-Clare (2012), De Locker, Goldberg, Khandelwal, and Pavcnik (2012)). The present paper emphasizes that, in evaluating pro-competitive effects

[4]It can be shown that placing Krugman (1980) in each DFS industry (similar to Romalis (2004)) gives specialization regions and trade shares that only depend on trade costs, but are unaffected by fixed costs and hence structural transformation. I depart from monopolistic competition because it does not produce interesting results in the context of this paper, but assuming oligopolistic markets is also in accord with ample evidence on the presence of large firms, see Neary (2009) for references.

[5]That is, if discreteness of firms is not essential, or if fixed costs fall substantially over time. Given the lack of estimates of the long-run trends in fixed costs, I follow the standard approach in the literature that treats them as a deep parameter, e.g. Luttmer (2007). The results generalize to the case when fixed costs fall slower than marginal costs if the size of manufacturing sector is sufficiently small; increasing fixed costs would provide an independent source of trade growth (see discussion in Section 2.4).

of trade, it is important to distinguish between different sources of trade growth.

My paper relates to three strands of the literature. First, it contributes to the studies explaining trade growth. A well-known worldwide trend is that trade has grown substantially relative to GDP over the last several decades. Meanwhile, tariff reductions have been quite moderate in developed countries – and transportation costs have not fallen that much either (Hummels (1999)) – which turns the amount of trade growth into a major quantitative puzzle.[6] In an influential paper, Yi (2003) argues that vertical specialization greatly magnifies the impact of tariff reduction, especially when trade costs become small, yet a large part (about a half) of the trade growth puzzle still remains.[7] A natural response to this striking evidence would be to look for alternative sources of trade growth. Thus, Dalton (2009) explores the adoption of just-in-time logistics; Feinberg and Keane (2006) argue for technical change (increasing role of intra-firm intermediates) in the context of multinational corporations. The contribution of this paper is to develop a parsimonious model that introduces structural change in the trade growth debate. For empirical relevance, the main distinction of the mechanism proposed here is that it operates and produces quantitatively significant results with costly trade, while the currently most successful vertical specialization story best works when total trade barriers, both natural and artificial, approach zero.

A second branch of related research is concerned with the interaction between trade and structural change. In the postwar period, the major economies have been facing steadily declining expenditure and employment shares of manufacturing. Moreover, since the early 80s, for example in the U.S., the absolute number of manufacturing jobs has been falling as well. This paper argues that the two historical trends (structural change and growth of trade) have a common source which is the growing manufacturing produc-

[6] As cited in Debaere and Mostashari (2010), the implied values of trade elasticity can go from 10 all the way to 30, which is an order of magnitude greater than usually found in the literature, e.g. Simonovska and Waugh (2011). Such high values may look particularly unencouraging in light of Arkolakis et al. (2012), as they imply negligible welfare effects of trade. Although the author's personal view is that trade research should not be guided by temptation to find big gains from trade, this paper makes a step to relax what can be called an unpleasant trade-off between the models' ability to explain trade growth and suggest significant welfare gains from globalization, a point also made by Yi (2003).

[7] Important motivating evidence for my study also comes from the empirical literature that looks at the relation between extensive margin movements and tariff reductions. Debaere and Mostashari (2010) summarize earlier studies and present new results that the estimated link appears weak. This, in part, challenges the quantitative results of Yi (2003) that rely on extensive margin adjustment. Furthermore, it remains unclear whether natural trade barriers (ignored in the calibration) can be considered small enough, such that trade tariffs approaching zero initiate the nonlinearity effect emphasized by Yi. On the other hand, Bridgman (2012) adds one more stage of production and finds that trade growth is consistent with the fall in directly measured trade costs. The magnitude of trade barriers used in his calibration is, however, much smaller than found, for example, in Anderson and van Wincoop (2004).

tivity and are linked through increasing returns to scale.[8] The literature relating trade and structural change has been focusing on one direction: The effect of trade openness on sectoral composition of consumption, output, and employment (Matsuyama (2009), Yi and Zhang (2010)).[9] This study investigates a particular aspect of the other direction: The effect of structural change on trade growth relative to GDP. One notable paper that also addresses the question whether structural transformation (due to nonhomethetic preferences) combined with increasing returns (in a monopolistic competition environment) can generate a rising trade-to-GDP ratio is Bergoeing and Kehoe (2003). However, their calibration results are that nonhomothetic preferences cannot account for the observed growth of trade relative to GDP. Bergoeing, Kehoe, Strauss-Kahn, and Yi (2004) reach the same conclusion and argue that vertical specialization as in Yi (2003) is needed to reconcile the growing manufacturing trade with the falling GDP share of manufacturing output.[10] The key difference between my approach and Bergoeing and Kehoe (2003) is that they do not have comparative advantage forces to be augmented by structural transformation. Yi and Zhang (2010) have structural change and comparative advantage but no increasing returns. To my knowledge, the present paper is the first to combine all of these elements. It is the interaction between increasing returns, cross-country technological differences, and transportation costs that stimulates specialization and trade as manufacturing productivity grows and manufacturing employment falls in the process of structural transformation.

Finally, the paper is related to the literature on oligopoly in general equilibrium. One central insight of this literature, e.g. Neary (2009), is that firms are modeled as large relative to the industry but small in the economy, which allows studying strategic interactions in a tractable way. Unlike many papers employing the "continuum-quadratic" preferences, I do not depart from the traditional CES, which stresses that the modeled effect has primarily a supply-side nature. The model with price competition uses a simplified Bernard, Eaton, Jensen, and Kortum (2003) and extends it by adding fixed costs. The model with quantity competition developed in Appendix A.3 dates back to Brander and Krugman (1983) and bases on a simplified version of Atkeson and Burstein (2008). A distinctive feature of my analysis is endogenous market structure in which the mode of

[8] For the purposes of this paper, structural change is model as a simple Baumol effect, see Ngai and Pissaridis (2007) for a closed economy analysis. Engel's law, formalized by non-homothetic preferences, is the second important mechanism of structural transformation. Buera and Kobowsky (2009) discuss how well the integrated approach can match the data.

[9] Sposi (2012) studies how structural transformation in South Korea affected the country's composition of import and export.

[10] The explanation of trade growth suggested in this paper is complementary with Yi (2003).

competition responds to structural change.[11]

The rest of the paper is organized as follows. Section 2 explores a planner's problem in which specialization and trade pattern evolves in response to structural change. Section 3 then shows how similar effects arise in the market economy with oligopolistic competition. Section 4 concludes and discusses broader implications of the paper.

2 Planner's Allocation

Consider the Dornbusch-Fischer-Samuelson (1977) model of Ricardian trade between two countries with transportation costs which create a region of goods that are endogenously nontraded. I modify this framework by adding exogenously nontraded services and fixed costs of developing manufactured products. Introducing fixed costs also requires to modify the market environment. In this section, however, I sidestep this issue by looking at the planner's allocation.

2.1 Environment and Planner Optimality

A two-country world in populated with identical agents with the following preferences:

$$U(S, M) = \left(\alpha S^{1-1/\eta} + (1-\alpha) M^{1-1/\eta}\right)^{\eta/(\eta-1)}, \quad 0 \leq \alpha < 1,\ 0 \leq \eta < 1, \tag{2.1}$$

where S is consumption of services and M is aggregate consumption of manufactures:

$$M = \left(\int_0^1 q_i^{1-1/\sigma} di\right)^{\sigma/(\sigma-1)}, \quad \sigma > 0. \tag{2.2}$$

The condition $\eta < 1$ ensures that the direction of employment reallocation during structural transformation caused by a faster productivity growth in manufacturing is from manufacturing to services (Ngai and Pissaridis (2007)).

Agents inelastically supply L units of labor. Services are exogenously nontraded, while manufactures can be traded with iceberg costs determined by $\tau > 1$: τ units of a good need to be shipped from one country to supply one unit of this good in the other.

[11] A number of previous studies have looked how competition mode is affected by trade liberalization, see Chapter 4 in Etro (2009) for a review.

Services are produced with a constant returns to scale technology: $L_s = z_s S$, where L_s is labor input and z_s is unit labor requirement.

Operating each industry in each country requires the fixed costs f in terms of labor. I assume the maximum possible symmetry, so the two countries, Home and Foreign, are identical in everything but unit labor requirements in manufacturing industries which are mirror images of each other. The marginal costs in Home and Foreign are

$$c_i = z_m \widetilde{c}_i \text{ and } c_i^* = z_m \widetilde{c}_i^*, \;\; \widetilde{c}_i^* = \widetilde{c}_{1-i}, \;\; i \in [0,1], \tag{2.3}$$

where z_m is the inverse of the common manufacturing productivity and goods are ordered such that the Home's comparative advantage is declining, or $\widetilde{c}_i$, assumed differentiable, is strictly increasing: $\widetilde{c}_i' > 0$.

There is a global central planner who maximizes utility of the representative agent. Appendix A.1.1 provides a formal treatment of the planner's problem. According to the pattern of comparative advantage, Home has industries in the range $i \in [0, \lambda]$ and Foreign in the range $i \in [1-\lambda, 1]$, where $\lambda \leq 1$ and the parameters are restricted such that it is optimal to produce all goods in the world economy, so $\lambda \geq \frac{1}{2}$.[12] In parallel to the standard DFS setup, goods in the region $[1-\lambda, \lambda]$ are endogenously nontraded, as the technologies are relatively similar and comparative advantage does not overcome trade costs.

Optimal consumption of each good in Home satisfies

$$q_i = M\left(\frac{c_i}{P}\right)^{-\sigma} \text{ for } i \in [0,\lambda] \text{ and } q_i = M\left(\frac{\tau c_i^*}{P}\right)^{-\sigma} \text{ for } i \in [\lambda, 1], \tag{2.4}$$

where the manufacturing cost index P is given by

$$P = \left(\int_0^\lambda c_i^{1-\sigma} di + \int_\lambda^1 (\tau c_i^*)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}. \tag{2.5}$$

The labor resource constraint in Home is

$$L_s + \int_0^\lambda q_i c_i di + \int_0^{1-\lambda} \tau q_i^* c_i di + \lambda f = L, \tag{2.6}$$

in which labor is used to pay the fixed costs and to produce services and manufacturing goods. (2.6) reflects that goods in the range $i \in [0, 1-\lambda]$ are produced both for domestic

[12] This restriction is mild, unless the elasticity of substitution σ is very high. This assumption means that f is low enough, other things equal, and, as we will see, that z_m/z_s is separated enough from zero.

consumption and for export (q_i^* denotes consumption in Foreign).

Assuming away markups allows expressing the planner's problem of setting the optimal specialization cutoff λ in a particularly simple way:

$$\max_{\lambda\in[\frac{1}{2},1]} U\left(z_s, z_m, \lambda\right) = \frac{L-\lambda f}{\left(\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta P^{1-\eta}\right)^{\frac{1}{1-\eta}}}, \tag{2.7}$$

where the numerator is resources left after paying the fixed costs, and the denominator is the cost of living index that depends on z_s and (through P) on z_m and λ.

With zero fixed costs, the problem (2.7) collapses to minimizing the manufacturing cost index, and the value of z_m relative to z_s plays no role. That is, with constant returns to scale in manufacturing, specialization is solely determined by the pattern of comparative advantage and trade costs, which corresponds to the original DFS. More specifically, the cutoff λ minimizes $P\left(z_m, \lambda\right)$ given by (2.5).

$$\frac{\partial}{\partial\lambda} P\left(z_m, \lambda\right) = P^\sigma \frac{c_\lambda^{1-\sigma} - \left(\tau c_\lambda^*\right)^{1-\sigma}}{1-\sigma}. \tag{2.8}$$

Setting $\frac{\partial}{\partial\lambda}P = 0$ implies $c_\lambda = \tau c_\lambda^*$, so the difference in efficiency is exactly balanced by trade costs (z_m only affects the level of P, not its composition).

With $f > 0$, keeping manufacturing industries in each country is costly. There is now a trade-off between minimizing the cost of living and maximizing resources left after paying the fixed costs. As shown in Appendix A.1.1, taking the first order condition for (2.7) gives

$$\frac{\partial}{\partial\lambda} U\left(z_s, z_m, \lambda\right) = 0 \Leftrightarrow \frac{\partial}{\partial\lambda} P\left(z_m, \lambda\right) = -\frac{f}{M} < 0. \tag{2.9}$$

Therefore, the first order condition implies that $\frac{c_\lambda^{1-\sigma} - \left(\tau c_\lambda^*\right)^{1-\sigma}}{1-\sigma} < 0$, or $c_\lambda < \tau c_\lambda^*$. This means that the fixed costs immediately narrow specialization regions (since c_i is increasing, the cutoff λ is lower than in the original DFS), as additional opportunities for specialization should be exploited. But this is just comparing two different environments with and without fixed costs. The main message of this exercise is that the presence of fixed costs affects comparative statics with respect to relative productivity in manufacturing z_s/z_m which generates structural change.

Before proceeding to characterize the effects of structural change, we need to compute the key statistic of the model which is the trade share, the ratio of manufacturing export to output. To make a link to the data, it should be calculated in values. The following interpretation of the planner's problem allows us to do so. Observe that the role of the central planner is limited to set the optimal value of λ. Conditional on that, everything else can be determined by competitive equilibrium in which prices are equal to marginal costs. So P can in fact be interpreted as the manufacturing price index (with wages being normalized to one), and PM is the value size of manufacturing. Appendix A.1.2 proves the following

Proposition 2.1. *The trade share, given by*

$$\frac{\int_0^{1-\lambda} \tau q_i^* c_i di}{PM} = \left(1 + \frac{\int_0^{\lambda} \widetilde{c}_i^{1-\sigma} di}{\int_0^{1-\lambda} (\tau \widetilde{c}_i)^{1-\sigma} di} \right)^{-1}, \tag{2.10}$$

is decreasing in λ.

This is very straightforward, meaning that trade becomes a larger fraction of manufacturing as specialization narrows. Importantly, this proposition implies that productivity growth and general equilibrium conditions affect the trade share only by shifting the specialization cutoff λ. This property that, for a given elasticity σ, trade costs τ, and efficiency distribution, λ is a sufficient statistic for the trade share is fairly general and holds throughout the paper.[13]

2.2 Structural Change

Appendix A.1.3 proves the following proposition which, along with its market economy counterpart in the next section, is the central result of this paper.

Proposition 2.2. *For any initial allocation with $\lambda \in \left(\frac{1}{2}, 1\right)$, a decrease in z_m/z_s narrows specialization (λ falls).*

Proposition 2.2 characterizes the response of specialization to structural change. As productivity in manufacturing increases relative to productivity in services (z_m/z_s falls), labor moves away from manufacturing, putting more emphasis on the incentive to save on fixed costs. This forces the countries to deepen specialization by dropping the weakest comparative advantage industries. The region of endogenously nontraded goods shrinks,

[13] For log preferences ($\sigma = 1$), this share is just $1 - \lambda$, or λ is the share of the country's trade with itself, which, by coincidence, is consistent with notation in Arkolakis et al. (2012).

and, from Proposition 2.1, trade becomes a larger share of manufacturing output and consumption. In other words, structural change amplifies the natural comparative advantage relative to trade barriers, as fixed costs become a larger share of employment in manufacturing.

It is important to emphasize that all ingredients of the model are crucial for this result. Without increasing returns in the form of fixed costs,[14] specialization is similar to DFS and does not depend on the relative productivity. With zero iceberg costs, the countries completely specialize ($\lambda = \frac{1}{2}$) for all z_m/z_s. Finally, in economy with only manufacturing sector, changes in z_m have no impact on specialization, despite the fact that they affect the ratio of marginal costs to fixed costs.[15] In all these cases, the trade-to-manufacturing ratio does not change as the countries undergo structural transformation.

The next proposition looks at the extreme case when manufacturing productivity grows unboundedly relative to productivity in services.

Proposition 2.3. *There exists a strictly positive level of z_m/z_s below which the countries completely specialize.*

The proof is given in Appendix A.1.4. Low enough z_m/z_s implies $\lambda = \frac{1}{2}$ if the assumption that all goods are produced is satisfied (if not, which is the case when $\sigma > 1$ and z_m/z_s is close to zero, then $\lambda < \frac{1}{2}$, which also means complete specialization). This result is more than merely a technical detail, as it says that structural change potentially leads to the maximum possible specialization despite the remaining trade barriers.

2.3 Simulation Example

Consider the economy described in this section with $L = 100$, $f = 2$, $\alpha = 0.9$, $\eta = 0.3$, $\sigma = 4$, $\tau = 1.4$ and $\widetilde{c}_i^* = \exp(\gamma i)$ with $\gamma = 0.5$.[16] Consider a starting point $z_s = 2$,

[14]This nature of increasing returns is important. It can be shown that in a similar DFS-based model with an alternative form of increasing returns, namely external economies as in Grossman and Rossi-Hansberg (2010), structural change does not generate growth in the trade-to-manufacturing ratio, as specialization regions are scale-independent (when external economies reduce marginal costs in a multiplicative way).

[15]This can be seen directly from (2.7). When $\alpha = 0$, so there are no services in the economy, U is proportional to (the inverse of) z_m and it does not influence the choice of λ. Changes in f, however, still affect specialization.

[16]The value $\eta = 0.3$ corresponds to the preferred value in Ngai and Pissaridis (2007) who also consider an alternative $\eta = 0.1$ (the latter generates a stronger decline in manufacturing employment, which would increase the trade share in my model at a higher rate). The value $\gamma = 0.5$ is set more arbitrary. Eaton and Kortum (2002), for a different distribution of productivity, prefer the value of dispersion parameter $\theta = 8.28$ which implies a standard deviation in efficiency of 15 percent. In this model, the efficiency

$z_m = 1$. In the equilibrium services have 72% employment share and 63% value share. The specialization cutoff is $\lambda = 0.7$, and the trade share is 16.9%. The fixed costs are 5% of total employment in manufacturing.

Now introduce sector-biased productivity growth at the rate 1.03 in manufacturing and 1.01 in services. When z_m and z_s fall at these rates during 50 periods (z_s/z_m increases by factor 2.67), λ becomes 0.61 and the trade share becomes 21.1%. Services employment is now 83%, services value share is 82%, and the fixed costs become 7.3% of employment in manufacturing. The four percentage points increase in the trade share is significant relative to the initial level.[17]

Figure 1 illustrates the resulting path of trade shares and also considers alternative parameter values. If the path of trade shares becomes flat, that means that λ achieves its lower bound $\frac{1}{2}$ (maximum specialization) and there is no further trade growth. In part A, a lower elasticity of substitution corresponds to a lower initial trade share and its slower increase. Part B shows that less variation in efficiency (lower γ) decreases the initial trade share but makes it grow faster in response to structural change. Part C shows that lower trade costs increase the initial trade share but reduce its responsiveness to structural change. Finally, part D illustrates that higher fixed costs both shift the path of trade shares upwards and make it steeper (unless λ becomes one half).

Structural change has a bigger impact on the trade share when the elasticity of substitution is higher, the pattern of comparative advantage is flatter, or the fixed costs are higher. The main requirement is, however, that trade costs are not very low. In this model, trade costs matter very little for structural transformation. Changing τ from 2 to 1.2 increases the services employment share from 71.5% to 72.5% in the starting period and form 82.7% to 83.6% in the final period. This suggests that the effect of trade on structural change is very small, but the effect of structural change on trade can be substantial provided that trade costs are nontrivial.[18]

$\exp(-\gamma i)$ has the standard deviation $\left(\frac{\gamma}{2}\frac{1+\exp(-\gamma)}{1-\exp(-\gamma)} - 1\right)^{0.5}$, which equals 0.15 for $\gamma = 0.52$. Simonovska and Waugh (2011) argue for a lower value of θ implying more variability.

[17] In this exercise I abstract from population growth. I approximately target the 30% drop in the absolute number of manufacturing jobs between 1980 and 2005 in the U.S. which happened despite growing labor force. As calculated in Yi (2003), the U.S. manufacturing trade share increased from 14% in 1980 to 27% in 2000. The differentiated productivity growth in manufacturing and services of 3% vs. 1% is stronger than estimated in Ngai and Pissaridis (2007) (2% vs. 1%). And, of course, there are only 25 years between 1980 and 2005, rather than 50 years. To generate a sufficient structural change with a narrower gap in productivity growth, I would need to reduce η or extend the model to include nonhomothetic preferences.

[18] The former result in this model can be due to similarity of countries and may change in a richer cross-section that exhibits heterogeneity in, for example, sector-level comparative advantage. Matsuyama

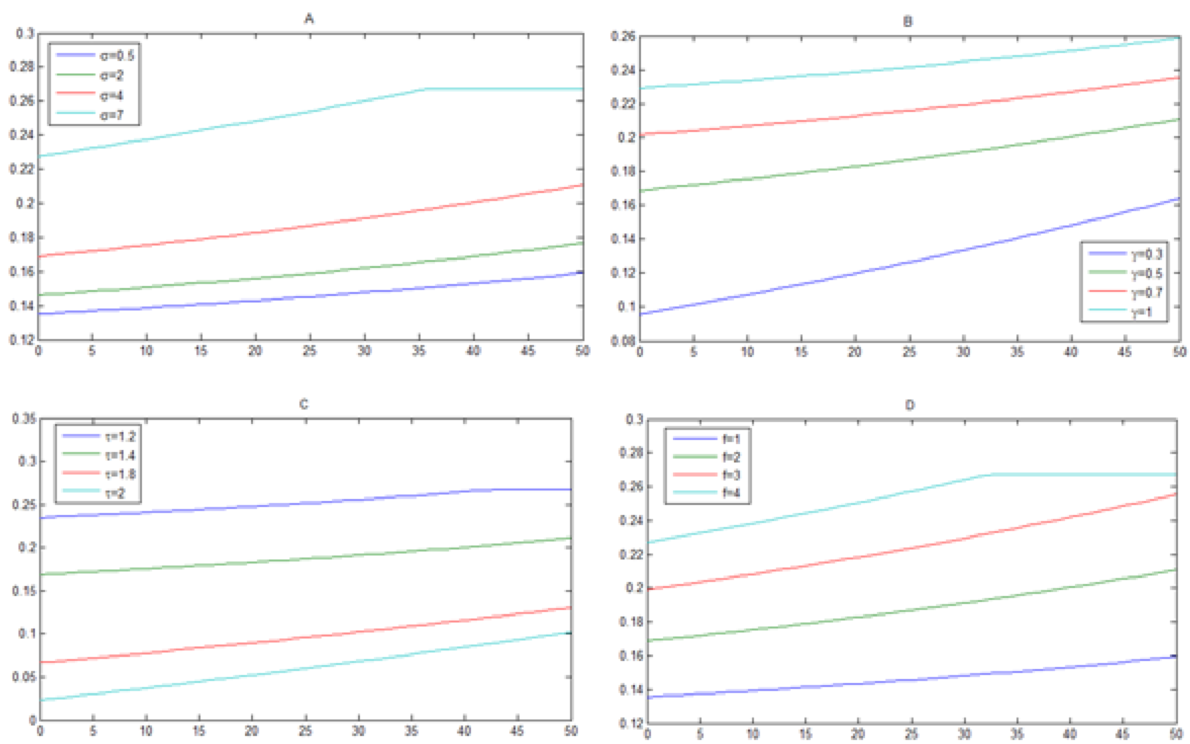

Figure 1: Comparative statics of the trade share in z_m/z_s for different parameter values. Benchmark: $\sigma = 4$, $\tau = 1.4$, $\gamma = 0.5$, $f = 2$.

2.4 Trade Liberalization

I now briefly discuss the role of trade costs in the model. In some sense, structural transformation acts as a substitute for trade liberalization: It increases the range of traded goods, up to the maximum level corresponding to frictionless trade, while zero trade costs leave no role for structural change to affect the trade share. The interaction between structural change and trade liberalization is, however, more complicated. As in DFS, a fall in trade costs leads to a higher trade share in the model presented. But lower trade costs have a similar effect as productivity improvements in manufacturing. By this, there arises a trade-induced structural change which (similar to Proposition 2.2) acts to amplify the effect of reduction in tariffs or transportation costs.[19]

2.5 Discussion

To summarize, this section establishes the presence of a fundamental force that increases trade specialization in response to declining manufacturing employment. So far this result relies on the planner's allocation, but in the next section I show that this force operates in the market economy as well. Structural change is found to be a new, not related to trade liberalization, source of trade growth.

The key assumption made to get these results is the presence of fixed costs. I follow the literature that, in a variety of settings, treats them as a deep parameter. In Luttmer (2007), a combination of constant fixed costs and marginal costs that are falling over time due to technological progress produces a distribution of firm sizes that is consistent with the data. In industrial organization, it is typical to assume that fixed costs are a random draw from a time-invariant distribution. With the interpretation that fixed costs capture such expenses as product development and managerial effort, they are likely to have a nature quite different from marginal costs.[20] Given the lack of estimates of the long-run

(2009) emphasizes that the global pattern of manufacturing decline realizes differently country by country. Teignier (2012) finds that trade has played an important role in structural transformation in particular countries. Ricardo Reyes-Heroles, in his third-year paper, shows that trade liberalization can have a bigger impact on structural change when trade is unbalanced.

[19] I do the following numerical exercise that sheds light on the nature of this interaction effect. Keeping z_s and z_m fixed, I simulate a path of trade shares that results from a declining path of τ. I compare this path to a counterfactual that is computed freezing employment is manufacturing at the initial level. The former path is always above, but the difference is small. This, again, demonstrates that trade in the model affects structural change only moderately, which is in contrast to a much stronger effect in the opposite direction.

[20] A similar argument can be made about fixed costs of exporting. Lincoln and McCallum (2011) test a hypothesis that these costs have declined and reject it.

trends in fixed costs, I assume them constant, which seems to be a reasonable benchmark.

The results generalize to the case when fixed costs fall slower than marginal costs, but under additional assumption that the size of manufacturing sector is sufficiently small. Increasing fixed costs would provide an independent source of trade growth.

The simple model presented in this section can already be of some empirical interest. As long as the mechanism that stimulates specialization in response to structural change applies to different levels of aggregation (intermediate goods and components), the effect can be even stronger and thus contribute a fair share to the explanation of the trade growth puzzle. The most restrictive requirement is that trade costs are not very low, that is above 20-30%. This number is substantially higher than used in the vertical specialization literature to generate the powerful nonlinearity effect, but still lower than estimated in the quantitative models of trade following Eaton and Kortum (2002).

3 Oligopoly

The main goal of this section is to demonstrate that the key result that structural change increases trade is not an artifact of the planner's formulation but holds in the market economy as well. On top of exactly the same fundamentals as in the planner's problem, I consider oligopolistic market structure where each industry in each country has one potential producer of a good who serve internationally segmented markets competing a la Bertrand. If, however, a (less efficient) firm cannot cover the fixed costs, it does not enter leaving both markets to its foreign competitor who is then a monopolist. This imposes an additional restriction $\sigma > 1$, which is the only change in the primitives relative to Section 2. The market structure (competition mode by industry) is endogenous and will respond to structural change.

3.1 Model Setup

Consider the Home country. From the preferences (2.1)-(2.2), the relative expenditure on services and manufacturing goods is

$$\frac{z_s S}{PM} = \left(\tfrac{\alpha}{1-\alpha}\right)^{\eta} \left(\frac{z_s}{P}\right)^{1-\eta}, \tag{3.1}$$

where the price of competitively produced services is given by unit labor cost z_s (wages are normalized to one), and the manufacturing price index $P = \left(\int_0^1 p_i^{1-\sigma} di\right)^{1/(1-\sigma)}$ aggregates the goods prices p_i, $i \in [0, 1]$, faced by Home consumers. The demand for each good i is

$$q_i = M \left(\frac{p_i}{P} \right)^{-\sigma}. \tag{3.2}$$

Similar to (2.3), firms in Home and Foreign have marginal costs

$$c_i = z_m \widetilde{c}_i \text{ and } c_i^* = z_m \widetilde{c}_i^*, \;\; \widetilde{c}_i^* = \widetilde{c}_{1-i}. \tag{3.3}$$

The simplest way to describe competition and pricing in manufacturing is to present it as a perturbation of a simplified BEJK setup. Suppose that in each industry in each country there is one potential producer which may enter paying the fixed costs f (for the beginning put $f = 0$). Once a firm exists, it can export with iceberg transportation costs $\tau > 1$. The markets in Home and Foreign are segmented, which results into variable markups. The competition is Bertrand, so all markets are served by only one producer that can offer the lowest price. Industries in the range $i \in [0, \lambda^0]$, where Home has comparative advantage, are served by Home firms and get prices $p_i = \min\{\frac{\sigma}{\sigma-1} c_i, \tau c_i^*\}$. Industries in the range $i \in [\lambda^0, 1]$ are served by Foreign firms, and the prices are $p_i = \min\{c_i, \frac{\sigma}{\sigma-1} \tau c_i^*\}$. A typical price profile that arises is presented in Figure 2.A. (The picture depends on σ, τ, as well as on the pattern of comparative advantage.) The specialization cutoff λ^0 (the abscissa of point B) is the same as in DFS, yet prices are higher because of positive markups. The goods in the range $i \in [1 - \lambda^0, \lambda^0]$ are endogenously nontraded.

Now add (small) fixed costs $f > 0$. To avoid losses, Home firms in the range $i \in [\lambda, 1]$ do not enter, where $\lambda < \lambda^0$. The marginal Home firm in the industry $i = \lambda$ that decides to enter enjoys effective (adjusted for trade costs that its foreign competitor needs to pay) efficiency advantage just enough to cover the fixed costs. Its gross profit is given by

$$\Pi_\lambda = (p_\lambda - c_\lambda) M \left(\frac{p_\lambda}{P} \right)^{-\sigma} = f. \tag{3.4}$$

Foreign firms in the range $i \in [\lambda, 1]$ are now monopolists not constrained by competition from Home and always set $p_i = \frac{\sigma}{\sigma-1} \tau c_i^*$. Similarly, all Home firms become unconstrained for $i \in [0, 1-\lambda]$ and set $p_i = \frac{\sigma}{\sigma-1} c_i$. For $i \in [1-\lambda, \lambda]$, where two firms enter (to serve their domestic markets only), competition is Bertrand and the prices are as in BEJK (above). Figure 2.B shows a typical price profile in Home. (A similar discontinuity as BF, which is where the new λ is, can arise for $i = 1 - \lambda$.)

I focus on the case when the range of nontraded goods, which corresponds in this setup to entry of both firms, is nondegenerate. Although this condition is quite reasonable and

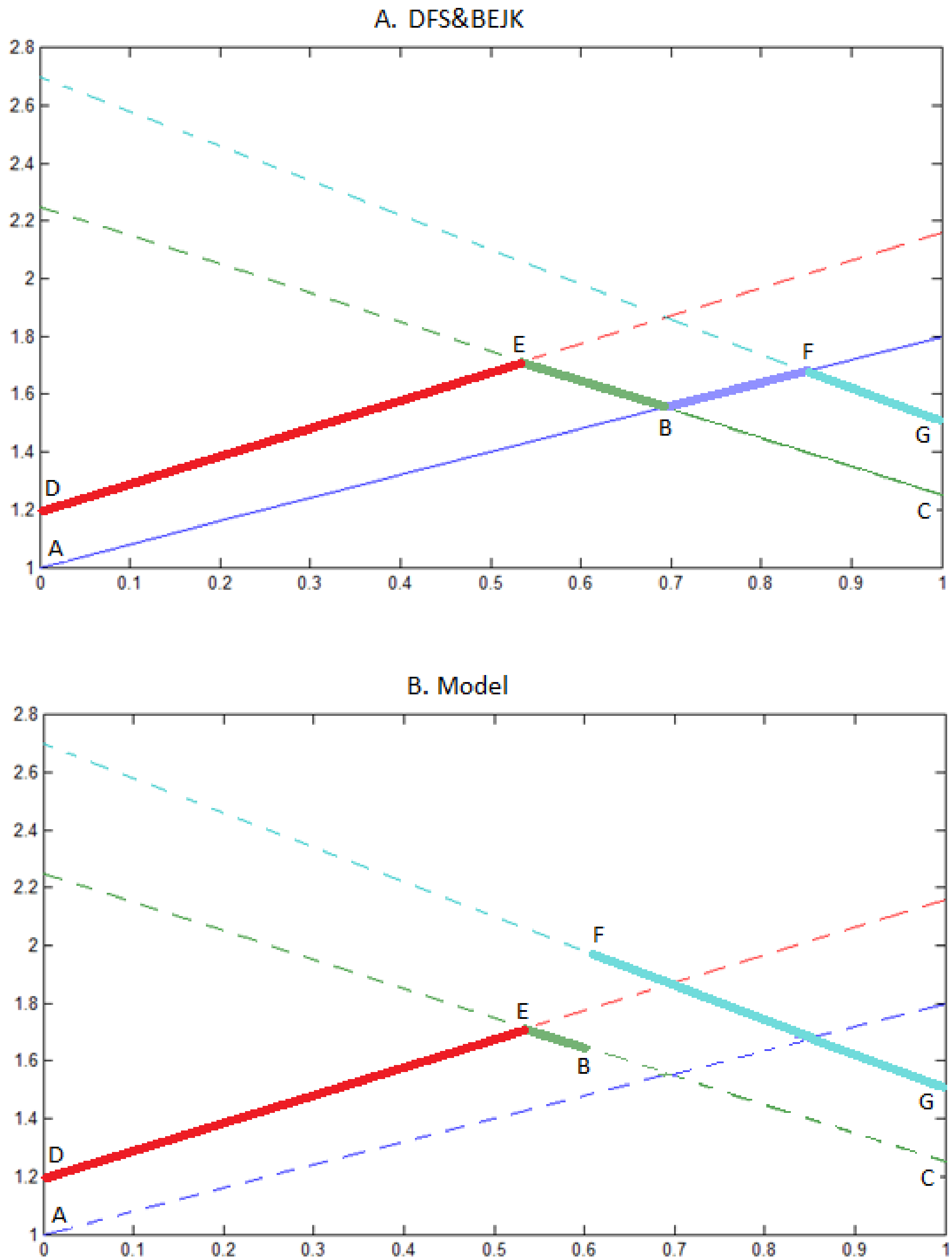

Figure 2: Prices by industry in Home. Parameters: $\sigma = 6$, $\tau = 1.25$, $c_i = 1 + 0.8i$.
Part A: Prices in DFS are given by the line ABC in which $AB = c_i$ and $BC = \tau c_i^*$; prices in BEJK are $DEBFG$ where $DE = \frac{\sigma}{\sigma-1} c_i$, $EB = \tau c_i^*$, $BF = c_i$, and $FG = \frac{\sigma}{\sigma-1} \tau c_i^*$.
Part B: Prices in the model are $DEBFG$.

unrestrictive (empirically, it relates to trade shares far below one half), in this setting it is powerful. For the market structure that arises in general equilibrium, the fact that the firms in the industry $i = \frac{1}{2}$ stay in business in both countries means that firms with this or better cost advantage can cover the fixed costs from serving domestic market only independently of the presence of the competitor. Therefore, to enter is a dominant strategy for the more efficient firm, by which the model avoids typical complications with multiple equilibria.[21] In what follows, although the fixed costs f will stay the same, the specialization cutoff λ will move in response to structural change generated by sector-biased productivity growth.

The manufacturing price index summarizing the market structure described above is

$$P = \left(\int_0^{1-\lambda} \left(\tfrac{\sigma}{\sigma-1} c_i\right)^{1-\sigma} di + \int_{1-\lambda}^{\lambda} \left(\min\{\tfrac{\sigma}{\sigma-1} c_i, \tau c_i^*\}\right)^{1-\sigma} di + \int_{\lambda}^{1} \left(\tfrac{\sigma}{\sigma-1} \tau c_i^*\right)^{1-\sigma} di. \right)^{\frac{1}{1-\sigma}} \tag{3.5}$$

One can guess that a lower λ corresponds to a higher level of (3.5). The later part of this section will rely on this fact, but it should be formulated in a different way, because (3.5) also depends on z_m which affects λ in equilibrium. Observe that from (3.3) all prices in manufacturing are scaled by z_m. Introduce $\widetilde{x}$ for each variable x such that $x = z_m \widetilde{x}$ and thus $\widetilde{P} = \frac{1}{z_m} P$ is the constant-productivity price index in manufacturing. Appendix A.2.1 proves a result analogous to (2.8)-(2.9) which is stated in

Proposition 3.1. *For any equilibrium with* $\lambda \in \left(\frac{1}{2}, 1\right)$ $\frac{\partial}{\partial \lambda} \widetilde{P} < 0$.

As highlighted in Appendix A.2.1, the inequality $\widetilde{P}'_\lambda < 0$ in Proposition 3.1 is necessarily strict, because switching suppliers from domestic oligopolist to foreign monopolist in the industry $i = \lambda$ in Home strictly increases $\widetilde{p}_\lambda$ both due to a (weakly) higher markup and a fall in efficiency adjusted by trade costs (in equilibrium with $f > 0$, $\widetilde{c}_\lambda < \tau \widetilde{c}^*_\lambda$). The second effect is present in the planner's allocation as well (this fall in sourcing efficiency is optimal, as it is compensated by saving on the fixed costs).

Similar to Section 2, the trade share can be computed conditional on λ only, independently of the other general equilibrium conditions.

[21] To be clear, multiplicity is possible in the model, but if we start from one unique equilibrium (adding small enough fixed costs to BEJK with nonflat cost advantage and positive trade costs), structural change preserves uniqueness as long as the region of nontraded goods does not shrink completely.

Proposition 3.2. *The trade share, given by*

$$\frac{\int_0^{1-\lambda} p_i^* q_i^* di}{PM} = \left(1 + \tau^{\sigma-1} + \frac{\int_{1-\lambda}^{\lambda} \left(\min\{\frac{\sigma}{\sigma-1}\widetilde{c}_i, \tau\widetilde{c}_i^*\}\right)^{1-\sigma} di}{\int_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}\tau\widetilde{c}_i\right)^{1-\sigma} di}\right)^{-1}, \tag{3.6}$$

is decreasing in λ.

The proof is in Appendix A.2.2.

3.2 Specialization and Structural Change

Let us now turn to the central part of the model which is determination of the specialization cutoff λ. By Walras law, the specialization cutoff is equivalently pinned down by goods or labor market clearing taking into account (3.4). Applying the tilde notation, write it as

$$z_m M \widetilde{P}^{\sigma} \left(\widetilde{p}_\lambda - \widetilde{c}_\lambda\right) \widetilde{p}_\lambda^{-\sigma} = f. \tag{3.7}$$

At this point we can already obtain some preliminary intuition. Equation (3.7) implies a mapping from a firm's cost advantage to profitability. The expression $\left(\widetilde{p}_\lambda - \widetilde{c}_\lambda\right) \widetilde{p}_\lambda^{-\sigma}$, which is proportional to profit earned by the marginal Home firm λ, is decreasing in λ as the firm's efficiency deteriorates (proved in Appendix A.2.3). By Proposition 3.1, $\widetilde{P}$ is decreasing in λ as well. Consider an improvement in manufacturing productivity relative to productivity in services, a decrease in z_m/z_s, which generates structural change. Because of the induced intersectoral reallocation towards services, manufacturing demand rises less than one-for-one with manufacturing productivity, so $z_m M$ falls. Then, to satisfy (3.7), λ must fall. Therefore, structural change tilts the mapping from cost advantage to profitability, such that the level of competitiveness required to stay in business goes up.

Appendix A.2.3 explores the labor market clearing condition to formalize this reasoning and prove

Proposition 3.3. *For any initial equilibrium with* $\lambda \in \left(\frac{1}{2}, 1\right)$, *a decrease in* z_m/z_s *narrows specialization* (*λ falls*).

The proof in Appendix A.2.3 is conceptually intense, as it employs virtually all model's assumptions and intermediate results, but makes no explicit use of $z_m M$ which is substituted for. Going back to the zero cutoff profit condition (3.7), a fall in z_m/z_s leads to a lower value of λ and (equivalently) higher value of $\widetilde{P}^{\sigma}\left(\widetilde{p}_{\lambda}-\widetilde{c}_{\lambda}\right)\widetilde{p}_{\lambda}^{-\sigma}$. Therefore, the proof establishes that $z_m M$ is in fact falling in z_s/z_m, confirming our intuition that structural change makes manufacturing demand grow less than one-for-one with manufacturing productivity, thus raising the required level of competitiveness.[22] In other words, the fact that services absorb an increasing expenditure and employment share leads to stronger selection among manufacturing firms. This effect is reminiscent of Melitz (2003), but here it takes the form of inter-industry reallocation,[23] and also the nature of the exogenous shocks is different (sector-biased productivity growth rather than trade liberalization).

Together with Proposition 3.2, Proposition 3.3 implies that, similar to the planner's allocation, structural change increases the trade share in the market economy with oligopolistic competition.

The main difference between the planner and the market economy comes from endogenous response of the market structure. Structural transformation in the model is unambiguously associated with growing monopolization. This translates into weakly increasing markups (staying constant if high trade costs do not restrict pricing of the marginal firms in domestic markets), which means that the manufacturing price index becomes weakly higher relative to its cost index analog from the planner's problem. As long as an increase in markups (other things equal) is equivalent to a productivity drop, this comparison indicates that, in a model with oligopolistic competition, endogenous response of the market structure damps down the effects of structural change. Nevertheless, the direction of the effect on the trade share is not reversed, so trade growth can happen simultaneously with increasing markups. This is in contrast to the pro-competitive effect of trade found in many models studying the impact of trade liberalization. An implication of this paper is that the term "pro-competitive effects of trade" may be misleading, as it is important to distinguish between different sources of trade growth.

[22] Although this makes intuitive sense from the beginning, it was necessary to show that the new features of the model (fixed costs and market structure that is endogenous to structural change) do not reverse this argument by adjustment of markups and saving resources on fixed costs as the weakest comparative advantage industries shut down.

[23] Intra-industry reallocation cannot be addressed with a model based on BEJK, even by adding more potential producers, but for the same reasons as in the paper structural change can affect selection within industries as well. Appendix A.3 shows that firms with different efficiency levels can coexist in the same market when competition is Cournot. Another way to incorporate within-industry heterogeneity is by considering differentiated varieties. Although combining inter- and intra-industry reallocation is of a big theoretical and empirical interest, this is left for future research. The simple framework developed in this paper best serves the purpose to introduce structural change as a new source of trade growth.

4 Conclusion

This paper shows that the interaction between comparative advantage, trade costs, and increasing returns stimulates specialization and trade as manufacturing productivity grows and manufacturing employment falls in the process of structural transformation. I establish this theoretical result by introducing fixed costs in an otherwise canonical Ricardian trade model extended to include a nontradable sector. Structural change amplifies comparative advantage forces relative to trade barriers, thus raising the manufacturing trade share for the same level of trade costs. This fact helps to explain the trade growth puzzle and, in particular, the weak relation of the extensive margin of trade to tariff reductions observed in the data.

The key feature of the model that accounts for these findings is the presence of fixed costs that are paid at the industry level, or firms are modeled as discrete, large relative to the industry. Exploring this feature produces a set of new theoretical results: i) The trade share varies for a constant level of trade costs, and trade specialization can achieve its maximum level with positive or even high trade costs; ii) The trade-induced structural change amplifies the effect of tariff reduction; iii) Inter-sectoral reallocation towards nontradables induces inter-industry reallocation in tradables towards the industries with stronger comparative advantage; iv) Structural change raises the required level of competitiveness, which leads to stronger inter-industry selection and increases the average productivity in tradables; v) Structural change increases industry concentration and markups.[24]

The simulation exercise suggests that the simple framework developed in the paper can already be of some empirical interest. Structural change can produce quantitatively significant effects on trade when trade costs are nontrivial. This new explanation of trade growth complements vertical specialization which best works when trade becomes nearly frictionless (in contrast, the effect of structural change on trade vanishes when trade costs approach zero).

There remains a number of additional questions that can be studied within the frame-

[24] One more result, not emphasized in this draft, concerns the redistribution effect of structural change. In general, the model has an ambiguous prediction on income redistribution between workers and entrepreneurs. On the one hand, increasing markups raise profits. Moreover, it is easy to show that the fact that the range of industries, or the measure of firms, declines does not itself reduce total (net or gross) profits, because domestic firms in the industries to right of $i = 1 - \lambda$ become exporters and get additional profits that outweigh the lost profits of the (less efficient) firms to the left of $i = \lambda$. On the other hand, there is a common decline in manufacturing profitability caused by reallocation to services. Whether workers or entrepreneurs gain more from sector-biased technological progress depends on the parameters of the model.

work presented. What are the model's implications for the gains from trade, how do they change in the process of structural transformation, do the new features introduced in the model require a modification of Arkolakis, Costinot, and Rodriguez-Clare (2012)? What are the effects of asymmetries between countries, which can include differences in population size, absolute advantage in particular sectors, or different stages of structural transformation? What are the redistributional effects of structural change in a model with imperfect competition and endogenous markups? What are the policy implications of the oligopoly model and how are they affected by structural change?

Meanwhile, using the model for sharper empirical investigations would require major extensions of the setup. In particular, as discussed in Bernard, Jensen, Redding, and Schott (2007), intra-industry reallocation is found in the data to be more important than inter-industry reallocation. Inability to address the former and link it to structural change is an obvious limitation of this study. Nevertheless, I would emphasize the broader implications of the paper. In particular, the central idea that structural transformation induces inter-industry reallocation by raising the required level of competitiveness can be applied to intra-industry reallocation as well. This paper thus offers a mechanism that can potentially be useful in other settings in macroeconomics and international trade.

A Appendix

A.1 Proofs for Section 2

A.1.1 Planner's Problem

Given the well-understood solution to the standard DFS model and maximum symmetry imposed by assumptions, I start with a simplified formulation of the planner's problem. Home has industries $i \in [0, \lambda]$ and Foreign has industries $i \in [1-\lambda, 1]$; goods in the region $[1-\lambda, \lambda]$ are endogenously nontraded. The parameters of the model are restricted to ensure that $\lambda \in [\frac{1}{2}, 1]$, so that each good is produced at least in one country. This restriction is a mild one, unless the elasticity of substitution σ is very high.

I solve the planner's problem backwards in two steps. Stage one is setting λ, and stage two is allocation of resources conditional on λ. Observe that stage two can actually be decentralized by considering a hypothetical economy in which all markets are perfect and consumers supply $L - \lambda f$ units of labor. With constant returns to scale and nested CES preferences, we can immediately express welfare as (2.7) simply by applying the standard

CES price index formula.

To obtain (2.9), first take the log of U and then use the equilibrium conditions from the stage two competitive economy analogy that $L - \lambda f = z_s S + PM$ (wages are normalized to one) and $\frac{z_s S}{PM} = \left(\frac{\alpha}{1-\alpha}\right)^{\eta} \left(\frac{z_s}{P}\right)^{1-\eta}$.

$$\log U = \log\left(L - \lambda f\right) - \frac{1}{1-\eta} \log\left(\alpha^{\eta} z_s^{1-\eta} + \left(1-\alpha\right)^{\eta} P^{1-\eta}\right).$$

$$\frac{\partial}{\partial\lambda} \log U = \frac{-f}{L-\lambda f} - \frac{\left(1-\alpha\right)^{\eta} P^{-\eta}}{\alpha^{\eta} z_s^{1-\eta} + \left(1-\alpha\right)^{\eta} P^{1-\eta}} \frac{\partial}{\partial\lambda} P = 0 \Rightarrow$$

$$\left(1-\alpha\right)^{\eta} P^{-\eta} \frac{\partial}{\partial\lambda} P = \frac{-f}{L-\lambda f} \left(\alpha^{\eta} z_s^{1-\eta} + \left(1-\alpha\right)^{\eta} P^{1-\eta}\right) \Rightarrow$$

$$\frac{1}{P} \frac{\partial}{\partial\lambda} P = \frac{-f}{L-\lambda f} \left(\left(\tfrac{\alpha}{1-\alpha}\right)^{\eta} \left(\frac{z_s}{P}\right)^{1-\eta} + 1\right) = \frac{-f}{L-\lambda f} \frac{z_s S + PM}{PM} \Rightarrow$$

$$\frac{\partial}{\partial\lambda} P = -\frac{f}{M}.$$

For values of λ satisfying $\frac{\partial}{\partial\lambda} U\left(z_s, z_m, \lambda\right) = 0$, $\frac{\partial^2}{\partial\lambda^2} U\left(z_s, z_m, \lambda\right) < 0$, so the first order condition is sufficient for a local interior maximum $\lambda \in \left(\frac{1}{2}, 1\right)$. High enough f or low enough z_m/z_s implies either the corner solution $\lambda = \frac{1}{2}$ or $\lambda < \frac{1}{2}$. These two cases are different. The latter is assumed away as abnormal, while the former necessarily arises for any $f > 0$ as z_m/z_s goes to zero even if $\sigma \leq 1$, see the proof in Appendix A.1.4.

A.1.2 Proof of Proposition 2.1

Using (2.4), (2.5), and (2.3),

$$\frac{Export}{Manufacturing} = \frac{\int_0^{1-\lambda} \tau q_i^* c_i di}{PM} = \frac{MP^{\sigma} \int_0^{1-\lambda} \left(\tau c_i\right)^{1-\sigma} di}{PM} = \frac{\int_0^{1-\lambda} \left(\tau c_i\right)^{1-\sigma} di}{P^{1-\sigma}} =$$

$$= \frac{\int_0^{1-\lambda} \left(\tau c_i\right)^{1-\sigma} di}{\int_0^{\lambda} c_i^{1-\sigma} di + \int_{\lambda}^{1} \left(\tau c_i^*\right)^{1-\sigma} di} = \frac{\int_0^{1-\lambda} \left(\tau c_i\right)^{1-\sigma} di}{\int_0^{\lambda} c_i^{1-\sigma} di + \int_0^{1-\lambda} \left(\tau c_i\right)^{1-\sigma} di} = \left(1 + \frac{\int_0^{\lambda} \widetilde{c}_i^{1-\sigma} di}{\int_0^{1-\lambda} \left(\tau \widetilde{c}_i\right)^{1-\sigma} di}\right)^{-1}.$$

In this final expression, $\int_0^{\lambda} \widetilde{c}_i^{1-\sigma} di$ is clearly increasing in λ and $\int_0^{1-\lambda} (\tau \widetilde{c}_i)^{1-\sigma} di$ is decreasing, hence a lower specialization cutoff corresponds to a higher trade share. ■

A.1.3 Proof of Proposition 2.2

It is sufficient to look at the effect of z_m keeping z_s constant. Define $u(z_s, z_m, \lambda) = \log U(z_s, z_m, \lambda)$. Maximizing u is equivalent to maximizing U.

$$u(z_s, z_m, \lambda) = \log(L - \lambda f) - \frac{1}{1-\eta} \log\left(\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta P^{1-\eta}\right).$$

From (2.5) and (2.3), the manufacturing cost index can be written as

$$P = z_m \widetilde{P} = z_m \left(\int_0^{\lambda} \widetilde{c}_i^{1-\sigma} di + \int_{\lambda}^{1} (\tau \widetilde{c}_i^*)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}.$$

$$\frac{\partial}{\partial z_m} u = -\frac{(1-\alpha)^\eta \widetilde{P}^{1-\eta} z_m^{-\eta}}{\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta P^{1-\eta}}$$

$$\log\left(-\frac{\partial}{\partial z_m} u\right) = \log(1-\alpha)^\eta + (1-\eta)\log \widetilde{P} - \eta \log(z_m) - \log\left(\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta z_m^{1-\eta} \widetilde{P}^{1-\eta}\right)$$

$$\frac{\partial}{\partial \lambda} \log\left(-\frac{\partial}{\partial z_m} u\right) = \frac{1-\eta}{\widetilde{P}} \frac{\partial}{\partial \lambda} \widetilde{P} - \frac{(1-\eta)(1-\alpha)^\eta z_m^{1-\eta} \widetilde{P}^{-\eta}}{\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta z_m^{1-\eta} \widetilde{P}^{1-\eta}} \frac{\partial}{\partial \lambda} \widetilde{P} =$$

$$= (1-\eta) z_m \frac{\partial}{\partial \lambda} \widetilde{P} \left(\frac{1}{P} - \frac{(1-\alpha)^\eta P^{-\eta}}{\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta P^{1-\eta}} \right) =$$

$$= \frac{1-\eta}{P} \frac{\alpha^\eta z_s^{1-\eta}}{\alpha^\eta z_s^{1-\eta} + (1-\alpha)^\eta P^{1-\eta}} \frac{\partial}{\partial \lambda} P < 0$$

which is because of (2.9).

$$sgn\left(\frac{d\lambda}{dz_m}\right) = sgn\left(\frac{\partial^2}{\partial z_m \partial \lambda} u(z_s, z_m, \lambda)\right) = -sgn\left(\frac{\partial}{\partial \lambda} \ln\left(-\frac{\partial}{\partial z} u(z_s, z_m, \lambda)\right)\right) = +.$$

■

A.1.4 Proof of Proposition 2.3

As in Appendix A.1.1, now using $P = z_m \widetilde{P}$,

$$\frac{\partial}{\partial \lambda} \log U = \frac{-f}{L - \lambda f} - \frac{(1-\alpha)^{\eta} \widetilde{P}^{-\eta}}{\alpha^{\eta} z_s^{1-\eta} + (1-\alpha)^{\eta} P^{1-\eta}} z_m^{1-\eta} \frac{\partial}{\partial \lambda} \widetilde{P}.$$

With $z_m \to 0$, $\frac{\partial}{\partial \lambda} \log U$ converges to $\frac{-f}{L - \lambda f} < 0$. Therefore, the planner's problem does not have interior solutions for sufficiently small z_m (keeping z_s constant for simplicity; what matters is the ratio z_m / z_s). But $\log U \left(z_s, 0, \frac{1}{2}\right) > \log U \left(z_s, 1, \frac{1}{2}\right)$, so $\lambda = 1$ is not a solution. Therefore, low enough z_m implies setting $\lambda = \frac{1}{2}$.

■

A.2 Proofs for Section 3

A.2.1 Proof of Proposition 3.1

To save on notation, replace $\widetilde{P}$ with P, just keeping z_m constant. From (3.5),

$$P'_{\lambda} = P^{\sigma} \frac{\left(\min\{\frac{\sigma}{\sigma-1} c_{1-\lambda}, \tau c^*_{1-\lambda}\}\right)^{1-\sigma} - \left(\frac{\sigma}{\sigma-1} c_{1-\lambda}\right)^{1-\sigma} + \left(\min\{\frac{\sigma}{\sigma-1} c_{\lambda}, \tau c^*_{\lambda}\}\right)^{1-\sigma} - \left(\frac{\sigma}{\sigma-1} \tau c^*_{\lambda}\right)^{1-\sigma}}{1-\sigma}.$$

As $\min\{\frac{\sigma}{\sigma-1} c_{1-\lambda}, \tau c^*_{1-\lambda}\} \leq \frac{\sigma}{\sigma-1} c_{1-\lambda}$ and $\min\{\frac{\sigma}{\sigma-1} c_{\lambda}, \tau c^*_{\lambda}\} \leq \tau c^*_{\lambda} < \frac{\sigma}{\sigma-1} \tau c^*_{\lambda}$, raising each expression to the power $1 - \sigma < 0$ flips the side of the inequalities, which yields $P'_{\lambda} < 0$. Note that the resulting inequality is strict because switching from oligopoly to monopoly in the industry $i = \lambda$ in Home strictly increases p_{λ}. ■

A.2.2 Proof of Proposition 3.2

Using (3.2), (3.5), and (3.3),

$$\frac{Export}{Manufacturing} = \frac{\int_0^{1-\lambda} p^*_i q^*_i di}{PM} = \frac{MP^{\sigma} \int_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1} \tau c_i\right)^{1-\sigma} di}{PM} = \frac{\int_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1} \tau c_i\right)^{1-\sigma} di}{P^{1-\sigma}} =$$

$$= \frac{\int\limits_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}\tau c_i\right)^{1-\sigma} di}{\int\limits_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma} di + \int\limits_{1-\lambda}^{\lambda} \left(\min\{\frac{\sigma}{\sigma-1}c_i, \tau c_i^*\}\right)^{1-\sigma} di + \int\limits_{\lambda}^{1} \left(\frac{\sigma}{\sigma-1}\tau c_i^*\right)^{1-\sigma} di} =$$

$$= \frac{\int\limits_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}\tau c_i\right)^{1-\sigma} di}{\int\limits_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}c_i\right)^{1-\sigma} di + \int\limits_{1-\lambda}^{\lambda} \left(\min\{\frac{\sigma}{\sigma-1}c_i, \tau c_i^*\}\right)^{1-\sigma} di + \int\limits_{0}^{1-\lambda} \left(\frac{\sigma}{\sigma-1}\tau c_i\right)^{1-\sigma} di} =$$

$$= \left(1 + \tau^{\sigma-1} + \frac{\int\limits_{1-\lambda}^{\lambda} \left(\min\{\frac{\sigma}{\sigma-1}\widetilde{c}_i, \tau \widetilde{c}_i^*\}\right)^{1-\sigma} di}{\int\limits_0^{1-\lambda} \left(\frac{\sigma}{\sigma-1}\tau \widetilde{c}_i\right)^{1-\sigma} di}\right)^{-1}.$$

By a reason similar to that in Appendix A.1.2, this expression is decreasing in λ. ■

A.2.3 Proof of Proposition 3.3

First we prove that the "base profit" of the marginal firm $(p_\lambda - c_\lambda)\, p_\lambda^{-\sigma}$, which is proportional to its actual profit $(p_\lambda - c_\lambda)\, M \left(\frac{p_\lambda}{P}\right)^{-\sigma}$, falls as the firm's efficiency deteriorates (λ increases). Consider separately the two cases when price setting is not constrained by the foreign competitor and when it is. Case 1: $\frac{\sigma}{\sigma-1}c_\lambda < \tau c_\lambda^*$, so $p_\lambda = \min\{\frac{\sigma}{\sigma-1}c_\lambda, \tau c_\lambda^*\} = \frac{\sigma}{\sigma-1}c_i$. Then $(p_\lambda - c_\lambda)\, p_\lambda^{-\sigma} = \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma} c_\lambda^{1-\sigma}$ is decreasing, as $c_\lambda' > 0$. Case 2: $\frac{\sigma}{\sigma-1}c_\lambda > \tau c_\lambda^*$, so $p_\lambda = \min\{\frac{\sigma}{\sigma-1}c_\lambda, \tau c_\lambda^*\} = \tau c_i^*$. Then $(p_\lambda - c_\lambda)\, p_\lambda^{-\sigma} = (\tau c_\lambda^* - c_\lambda)\,(\tau c_\lambda^*)^{-\sigma}$. The derivative is

$$(\tau c_\lambda^*)^{-\sigma} \left(-c_\lambda' + c_\lambda^{*\prime} \left(\sigma \frac{c_\lambda}{c_\lambda^*} + (1-\sigma)\,\tau\right)\right) < 0,$$

which is implied by $\frac{\sigma}{\sigma-1}c_\lambda > \tau c_\lambda^*$. Considering case 3 $\frac{\sigma}{\sigma-1}c_\lambda = \tau c_\lambda^*$ is redundant because of continuity. Therefore, the "base profit" falls in λ independently of the mode of markup.

Now we can prove the comparative statics result of Proposition 3.3. The labor market clearing condition in Home is

$$L_s + L_m^v + \lambda f = L, \tag{A.1}$$

where $L_s = z_s S$ is employment in services and total manufacturing employment $L_m = L_m^v + \lambda f$ consists of labor spending on variable and fixed costs. The first component can be decomposed into three parts:

$$L_m^v = \int_0^{1-\lambda} q_i c_i di + \int_0^{1-\lambda} q_i^* \tau c_i di + \int_{1-\lambda}^{\lambda} q_i c_i di,$$

in which the first two parts are labor spending by Home monopolists serving Home and Foreign markets, and the last part is labor spending by Home oligopolists (facing competition from abroad) serving the domestic market. As soon as demand for manufactures in both countries is proportional to MP^σ, using the equilibrium prices we obtain

$$L_m^v = MP^\sigma \left(\left(1+\tau^{1-\sigma}\right) \left(\tfrac{\sigma}{\sigma-1}\right)^{-\sigma} \int_0^{1-\lambda} c_i^{1-\sigma} di + \int_{1-\lambda}^{\lambda} \left(\min\{\tfrac{\sigma}{\sigma-1} c_i, \tau c_i^*\}\right)^{-\sigma} c_i di \right).$$

Using this result and the equilibrium condition $\frac{z_s S}{PM} = \left(\frac{\alpha}{1-\alpha}\right)^\eta \left(\frac{z_s}{P}\right)^{1-\eta}$, we can write (A.1) as

$$MP^\sigma \left(\left(\tfrac{\alpha}{1-\alpha}\right)^\eta z_s^{1-\eta} P^{\eta-\sigma} + \kappa \int_0^{1-\lambda} c_i^{1-\sigma} di + \int_{1-\lambda}^{\lambda} \left(\min\{\tfrac{\sigma}{\sigma-1} c_i, \tau c_i^*\}\right)^{-\sigma} c_i di \right) + \lambda f = L,$$

where the constant $\kappa = \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}$.

Next use (3.7) to substitute for MP^σ and apply the $x = z_m \widetilde{x}$ notation. This yields

$$\left(\tfrac{\alpha}{1-\alpha}\right)^\eta \left(\tfrac{z_s}{z_m}\right)^{1-\eta} \widetilde{P}^{\eta-\sigma} + \kappa \int_0^{1-\lambda} \widetilde{c}_i^{1-\sigma} di + \int_{1-\lambda}^{\lambda} \left(\min\{\tfrac{\sigma}{\sigma-1} \widetilde{c}_i, \tau \widetilde{c}_i^*\}\right)^{-\sigma} \widetilde{c}_i di = \frac{L-\lambda f}{f} \left(\widetilde{p}_\lambda - \widetilde{c}_\lambda\right) \widetilde{p}_\lambda^{-\sigma}.$$

Note that z_m/z_s now only appears in one term. The right hand side is decreasing in λ (both $\frac{L-\lambda f}{f}$ and $\left(\widetilde{p}_\lambda - \widetilde{c}_\lambda\right) \widetilde{p}_\lambda^{-\sigma}$ are). By Proposition 3.1, the manufacturing price index is decreasing in λ, hence $\widetilde{P}^{\eta-\sigma}$ is increasing ($\eta < 1 < \sigma$). Next,

$$\frac{\partial}{\partial \lambda} \left(\kappa \int_0^{1-\lambda} c_i^{1-\sigma} di + \int_{1-\lambda}^{\lambda} \left(\min\{\tfrac{\sigma}{\sigma-1} c_i, \tau c_i^*\}\right)^{-\sigma} c_i di \right) > 0 \tag{A.2}$$

would give a sufficient condition that the whole left hand side is increasing in λ. Taking the derivative, (A.2) becomes

$$\left(\min\{\tfrac{\sigma}{\sigma-1}c_{1-\lambda},\tau c^*_{1-\lambda}\}\right)^{-\sigma}c_{1-\lambda}-\left(\tfrac{\sigma}{\sigma-1}\right)^{-\sigma}c^{1-\sigma}_{1-\lambda}+$$

$$+\left(\min\{\tfrac{\sigma}{\sigma-1}c_{\lambda},\tau c^*_{\lambda}\}\right)^{-\sigma}c_{\lambda}-\left(\tfrac{\sigma}{\sigma-1}\right)^{-\sigma}\left(\tau c_{1-\lambda}\right)^{1-\sigma}>0.$$

Showing that $\left(\min\{\tfrac{\sigma}{\sigma-1}c_{1-\lambda},\tau c^*_{1-\lambda}\}\right)^{-\sigma}c_{1-\lambda}\geq\left(\tfrac{\sigma}{\sigma-1}\right)^{-\sigma}c^{1-\sigma}_{1-\lambda}$ is similar to what we have done above for the "base profit".[25] Using the mirror symmetry of c_i and c_i^*, we rewrite the remaining condition as $\left(\min\{\tfrac{\sigma}{\sigma-1}c_{\lambda},\tau c^*_{\lambda}\}\right)^{-\sigma}c_{\lambda}>\left(\tfrac{\sigma}{\sigma-1}\right)^{-\sigma}\left(\tau c^*_{\lambda}\right)^{1-\sigma}$ and verify that it is always satisfied.[26]

By now we have shown that the left (right) hand side of the final equilibrium condition

$$\left(\tfrac{\alpha}{1-\alpha}\right)^{\eta}\left(\tfrac{z_s}{z_m}\right)^{1-\eta}\widetilde{P}^{\eta-\sigma}+\kappa\int_0^{1-\lambda}\widetilde{c}_i^{1-\sigma}di+\int_{1-\lambda}^{\lambda}\left(\min\{\tfrac{\sigma}{\sigma-1}\widetilde{c}_i,\tau\widetilde{c}^*_i\}\right)^{-\sigma}\widetilde{c}_idi=\frac{L-\lambda f}{f}\left(\widetilde{p}_\lambda-\widetilde{c}_\lambda\right)\widetilde{p}_\lambda^{-\sigma}$$

is increasing (decreasing) in λ. A decline in z_m/z_s shifts the right hand side upwards, yielding a lower value of λ in the intersection, which completes the proof. ■

A.3 A Model with Cournot Competition

This part of the paper formulates a model with quantity competition instead of price competition in Section 3 and gives a sketch of the solution.

The technology is the same. For simplicity, assume Leontief preferences: $U(S,M)=\min\{\alpha S,M\}$ and set $z_s=1$. Markets in Home and Foreign are again segmented; if a firm is the only supplier of good i in a country, it acts in that market as a monopolist;[27] if there are two suppliers, they engage in Cournot competition.

The partial equilibrium problem of solving a two-firm quantity competition model is standard. With CES preferences, despite cost asymmetry, it is still possible to obtain a

[25] If $\frac{\sigma}{\sigma-1}c_{1-\lambda}\leq\tau c^*_{1-\lambda}$, it is satisfied as equality. In the opposite case it becomes $\left(\tau c^*_{1-\lambda}\right)^{-\sigma}c_{1-\lambda}\geq\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}c^{1-\sigma}_{1-\lambda}$, which follows from $\frac{\sigma}{\sigma-1}c_{1-\lambda}>\tau c^*_{1-\lambda}$.

[26] For $\frac{\sigma}{\sigma-1}c_\lambda\geq\tau c^*_\lambda$, this inequality is $(\tau c^*_\lambda)^{-\sigma}c_\lambda>\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(\tau c^*_\lambda)^{1-\sigma}$, or $\frac{\sigma}{\sigma-1}c_\lambda\left(\frac{\sigma}{\sigma-1}\right)^{\sigma-1}>\tau c^*_\lambda$ (implied by $\frac{\sigma}{\sigma-1}c_\lambda\geq\tau c^*_\lambda$ and $\sigma>1$). For $\frac{\sigma}{\sigma-1}c_\lambda<\tau c^*_\lambda$, it is $\left(\frac{\sigma}{\sigma-1}c_\lambda\right)^{-\sigma}c_\lambda>\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(\tau c^*_\lambda)^{1-\sigma}$, which is simply $c_\lambda<\tau c^*_\lambda$. The last condition holds as soon as $f>0$ (specialization regions in the model are narrower than in DFS or BEJK).

[27] This assumption again limits the analysis to considering $\sigma>1$. By having more firms in each industry from each country it can be relaxed, but at costs of more cumbersome derivations.

closed-form solution given by the following

Proposition A.1. *Consider the following partial equilibrium problem. The demand for a good is given by* $Q = AP^{-\sigma}$, $\sigma > 1$. *There are two firms with constant marginal costs* z_1 *and* z_2. *Then: A) If* $\frac{\sigma-1}{\sigma} \leq \frac{z_2}{z_1} \leq \frac{\sigma}{\sigma-1}$, *Cournot competition yields the equilibrium price, quantities and profits given by* $P = \frac{\sigma}{2\sigma-1}(z_1+z_2)$, $q_j = A\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\frac{(1-\sigma)z_j+\sigma z_{-j}}{(z_1+z_2)^{1+\sigma}}$, $\Pi_j = A\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\frac{((1-\sigma)z_j+\sigma z_{-j})^2}{(2\sigma-1)(z_1+z_2)^{1+\sigma}}$. *B) If* $\frac{z_2}{z_1} > \frac{\sigma}{\sigma-1}$, *only the first firm survives and monopoly equilibrium is described by* $P = \frac{\sigma}{\sigma-1}z_1$, $q_1 = A\left(\frac{\sigma}{\sigma-1}z_1\right)^{-\sigma}$, $\Pi_1 = A\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\frac{z_1^{1-\sigma}}{\sigma-1}$.

The proof uses that best-response functions can be written as $P = \frac{\sigma}{\sigma-s_1}z_1 = \frac{\sigma}{\sigma-s_2}z_2$ where $s_1 = 1 - s_2 = \frac{q_1}{q_1+q_2}$.

Firms face marginal costs (2.3) with the same properties as in Section 2 (wages are normalized to one). To cover the complete variety of cases, assume now that there is enough variation in comparative advantage, such that $\frac{c_0^*}{c_0} = \frac{c_1}{c_0} > \frac{\sigma}{\sigma-1}\tau$. This will guarantee that structural change affects specialization and trade for arbitrary small fixed costs. (This assumption is not crucial to generate trade growth as a result of structural change.)

Using the above proposition (call it lemma) we can already characterize the trade pattern which would prevail in this economy with zero fixed costs. Home firms decide to enter in the range $i \in [0, \lambda]$ and firms in the range $i \in [0, \mu]$ also export, $\mu \leq \lambda$. Symmetrically, Foreign produces $i \in [1-\lambda, 1]$ and exports $i \in [1-\mu, 1]$. For $i \in [0, 1-\lambda)$ the Home firm has such a strong comparative advantage that the Foreign one cannot engage in Cournot competition even taking into account that c_i is adjusted by τ. That is, in this range $\frac{c_i^*}{c_i} > \frac{\sigma}{\sigma-1}\tau$ and the Home firm is monopolist in both markets. The marginal Foreign firm that exists is determined by $\frac{\sigma}{\sigma-1}\tau c_{1-\lambda} = c_{1-\lambda}^*$. In the range $i \in [1-\lambda, \mu)$ Home firms are still competitive enough to export, but now they face competition and have lower profits from exporting. The marginal Home exporter is determined by $\tau c_\mu = \frac{\sigma}{\sigma-1}c_\mu^*$.

Depending on demand elasticity and transportation costs, there can be two different configurations in the middle of the interval $[0, 1]$. If $\tau < \frac{\sigma}{\sigma-1}$, that is, transportation costs are lower than monopoly markup, the exporting cutoff $\mu > \frac{1}{2}$ and there is two-way trade in the region $i \in [1-\mu, \mu]$. In contrast, if $\tau > \frac{\sigma}{\sigma-1}$, $\mu < \frac{1}{2}$ and countries do not trade in the region $i \in [\mu, 1-\mu]$.

Now add the fixed costs $f > 0$. Unless f is too high, it does not affect the exporting cutoff μ because export decision is made conditional on existence. On the other hand, λ (or $1-\lambda$) is affected: the marginal (which just decides to enter; it serves only domestic market) Foreign firm $i = 1-\lambda$ makes variable profit just enough to cover the fixed costs:

$$\frac{1}{2\sigma-1}\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma} MP^{\sigma}\frac{\left(\left(1-\sigma\right)c^*_{1-\lambda}+\sigma\tau c_{1-\lambda}\right)^2}{\left(c^*_{1-\lambda}+\tau c_{1-\lambda}\right)^{1+\sigma}}=f. \tag{A.3}$$

Expression (A.3) is the key condition in this section. It is derived using the above lemma with $z_1 = c^*_{1-\lambda}$, $z_2 = \tau c_{1-\lambda}$ and demand $Q = q^*_{1-\lambda} = M\left(\frac{p^*_{1-\lambda}}{P}\right)^{-\sigma}$. The cutoff λ now depends on general equilibrium conditions. It is convenient to reintroduce wages for a while and rewrite (A.3) with $1f = Wf$ and $c_i = z_m\widetilde{c}_i W$:

$$\frac{1}{2\sigma-1}\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\frac{\left(\left(1-\sigma\right)\widetilde{c}^*_{1-\lambda}+\sigma\tau\widetilde{c}_{1-\lambda}\right)^2}{\left(\widetilde{c}^*_{1-\lambda}+\tau\widetilde{c}_{1-\lambda}\right)^{1+\sigma}}=\frac{f}{z_mM}\left(z_m\frac{W}{P}\right)^{\sigma}. \tag{A.4}$$

The left hand side is decreasing in λ (this is equivalent to the fact that the firm's profit in the lemma increases in the firm's costs advantage). To obtain some preliminary intuition, consider first a change, say, a decrease, in L for a constant z_m. If $\left(\frac{W}{P}\right)^{\sigma}$increases, stays constant or decreases less than proportionally to M, the left hand side should increase, so λ falls, which means deeper specialization. This demonstrates that the trade pattern is potentially scale-dependent in this setting. Next consider an increase in the common manufacturing productivity (z_m falls). In the economy with only manufacturing sector, as we will see below, both z_mM and $z_m\frac{W}{P}$ are constant because manufacturing output and the real wage change one for one with manufacturing productivity. However, if the economy features structural change, an increase in M is associated with declining manufacturing employment as labor moves away to less productive services. This means that z_mM decreases as z_m falls, so λ falls as well, generating more trade.

Labor market clearing in Home is

$$\alpha M+\int_0^{1-\mu} q_i^m c_i di+\int_{1-\mu}^{\lambda} q_i^o c_i di+\int_0^{1-\lambda}\tau q_i^{*m} c_i di+\int_{1-\lambda}^{\mu}\tau q_i^{*o} c_i di+\lambda f=L, \tag{A.5}$$

where $\int_0^{1-\mu} q_i^m c_i di$ is serving the Home market as monopolist, $\int_{1-\mu}^{\lambda} q_i^o c_i di$ is serving the Home market as oligopolist, $\int_0^{1-\lambda}\tau q_i^{*m} c_i di$ is serving the Foreign market as monopolist, and $\int_{1-\lambda}^{\mu}\tau q_i^{*o} c_i di$ is serving the Foreign market as oligopolist. Each of these four terms has a common factor MP^{σ}, so rewrite (A.5) as

$$MP^{\sigma}\left(\alpha P^{-\sigma}+z_m^{1-\sigma}H\left(\tau,\sigma,\mu\left(\tau,\sigma\right),\lambda\right)\right)=L-\lambda f$$

and then substitute MP^{σ} from (A.3) to get

$$\frac{\alpha}{z_m}\left(\widetilde{P}\left(\tau,\sigma,\mu\left(\tau,\sigma\right),\lambda\right)\right)^{-\sigma}+H\left(\tau,\sigma,\mu\left(\tau,\sigma\right),\lambda\right)=\frac{L-\lambda f}{f}\frac{1}{2\sigma-1}\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\frac{\left((1-\sigma)\widetilde{c}^{*}_{1-\lambda}+\sigma\tau\widetilde{c}_{1-\lambda}\right)^{2}}{\left(\widetilde{c}^{*}_{1-\lambda}+\tau\widetilde{c}_{1-\lambda}\right)^{1+\sigma}}$$

where

$$\widetilde{P}=\left(\int_{0}^{1-\mu}\left(\frac{\sigma}{\sigma-1}\widetilde{c}_i\right)^{1-\sigma}di+\int_{1-\mu}^{\lambda}\left(\frac{\sigma}{2\sigma-1}\left(\widetilde{c}_i+\tau\widetilde{c}^{*}_i\right)\right)^{1-\sigma}di+\int_{\lambda}^{1}\left(\frac{\sigma}{\sigma-1}\tau\widetilde{c}^{*}_i\right)^{1-\sigma}di\right)^{\frac{1}{1-\sigma}}$$

$$H\left(\tau,\sigma,\mu\left(\tau,\sigma\right),\lambda\right)=\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\int_{0}^{1-\mu}\widetilde{c}_i^{1-\sigma}di+\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\int_{1-\mu}^{\lambda}\frac{(1-\sigma)\widetilde{c}_i+\sigma\tau\widetilde{c}^{*}_i}{\left(\widetilde{c}_i+\tau\widetilde{c}^{*}_i\right)^{1+\sigma}}\widetilde{c}_i di+$$
$$+\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\int_{0}^{1-\lambda}\left(\tau\widetilde{c}_i\right)^{1-\sigma}di+\left(\frac{2\sigma-1}{\sigma}\right)^{\sigma}\int_{1-\lambda}^{\mu}\frac{(1-\sigma)\tau\widetilde{c}_i+\sigma\widetilde{c}^{*}_i}{\left(\tau\widetilde{c}_i+\widetilde{c}^{*}_i\right)^{1+\sigma}}\tau\widetilde{c}_i di.$$

The comparative statics pattern can be established as in Section 3.

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