Economies of Scale and International Business Cycles

Daisoon Kim*
London Business School

November 22, 2018
(Lastet version)

Abstract

This paper analyzes whether economies of scale are important in industrial and aggregate international business cycles when those economies arise from sloping marginal cost curves. I first provide a method to estimate the slopes of marginal cost curves and show that industry's international business cycle patterns vary systemically by the slopes. In line with these findings, I introduce sloping marginal cost curves and their variations across industries in an open economy macroeconomic model. It delivers endogenous export gains/losses and within-firm links between domestic and export markets which generate two attractive features of the model: (i) it raises model-implied cross-country aggregate GDP comovements which are close to the data, and (ii) it reproduces observed industrial international business cycle patterns. In industries with decreasing marginal costs, output, imports, and exports are all more correlated with aggregate GDP than in industries with increasing marginal costs. My results suggest that sloping marginal cost curves and their heterogeneity are informative to understand the international business cycle.

JEL Classification: D24, F41, F44, L11

I am very grateful to Fabio Ghironi for his valuable advice and encouragement. I would like to thank John Geweke, Yu-chin Chen, Yoonsoo Lee, Alessandro Barattieri, Luca David Opromolla, Keith Head, Andrei Zlate, Federico Mandelman, Rory Mullen as well as seminar participants at 2018 Fall Midwest Macroeconomic Meetings, 88th Annual Meeting of Southern Economic Association, London Business School, the University of Washington, the University of Tokyo, Concordia University, and Sogang University for useful comments.

*Address: London Business School, Regent's Park, London, NW1 4SA, UK. Email: `dkim@london.edu` Web page: `https://sites.google.com/site/fatherofseoyoon`

1 Introduction

Although fixed costs are typically considered the only source of economies of scale in international macroeconomics, there are good reasons to introduce sloping marginal cost curves to the model. First, the introduction of upward sloping marginal cost curves can explain why some industries face diseconomies of scale shown in the data. Second, the sloping marginal cost curves cause within-firm interdependence between domestic and export markets. Firm's decisions in one market change its marginal costs of production that have impacts on its decisions in the other market. Third, they affect a firm's export decision through export gains or losses. For example, decreasing marginal costs cause that some firms export to lower their marginal costs even if their export market profit is negative.

This paper provides direct evidence of the sloping marginal cost curves in the data. Further, it investigates their role in international business cycles empirically and theoretically. These are where the paper attempts to make a contribution.

Canonical new trade models and open macro models such as Krugman (1979, 1980), Melitz (2003), and Ghironi and Melitz (2005) do not take an interest in their origins determined by fixed and marginal costs even though they have long recognized the importance of economies of scale.[1] Because of modeling tractability, they use a linear cost function. Thus, fixed costs solely generate economies of scale because the firm's marginal costs of production do not depend on how much it produces. This flat marginal cost curve causes the domestic and export profits to be linearly separable. Thus, the individual firm's decisions in an export market are independent of their decisions in a domestic market, and vice versa. However, recent international trade studies such as Vannoorenberghe (2012), Soderbery (2014), Berman et al. (2015), and Almunia et al. (2018) cast doubt on the firm-level separability of two markets and document the within-firm level interdependence between the markets.[2] They give evidence for the necessity of sloping marginal cost curves.

[1] A wide range of international trade literature such as Tybout (1993), Harrigan (1994), and Antweiler and Trefler (2002) study empirical patterns between economies of scale and trade. They conclude that introducing economies of scale contribute to a better understanding of international trade. However, they are not interested in a source of economies of scale, too.

[2] Their results, especially the direction of the relationship, are rather mixed. First, Berman et al. (2015) conclude that an exogenous increase in foreign sales causes increases in domestic sales in French data. di Giovanni et al. (2016) document that internationally connected firms generate a positive relationship between an individual firm and the foreign economy. In contrast, some papers find that sales access markets are substitutes. Vannoorenberghe (2012) constructs a Melitz (2003) type trade model with increasing marginal cost to explain firm-level volatilities. Soderbery (2014) and Rho and Rodrigue (2016) assume constant returns to scale with capacity constraints, which induces increasing marginal costs in the short run. Both at the theoretical and empirical levels, the relationship between exports and domestic sales is not clear-cut. My empirical findings of industry heterogeneity of slope of the marginal cost curves suggest complementary relationships for some industries and substitute relationships for some industries.

The key feature of this paper, sloping marginal cost curve, is important for the generation and propagation of international business cycles through intensive and extensive margins. First, the sloping marginal cost curve endogenously generates the within-firm interdependence between domestic and export markets, which contributes aggregate comovements across countries. For example, a firm exports more during a foreign boom because of its high demand. If the firm faces a decreasing marginal cost curve, the fall in marginal costs by the increase in exports will augment its supply and profit but decrease its price in the domestic market. Thus, the downward (upward) sloping marginal cost curve generates positive (negative) within-firm market interdependence between domestic and export markets. Second, the sloping marginal cost curve also plays a crucial role in extensive margins of exports. A sloping marginal cost curve generates efficiency gains or losses from exporting. Fixed export costs force less productive firms not to export. A firm with a flat marginal cost curve only exports when its profit (excluding fixed export costs) in the export market is higher than the fixed export cost because its domestic market profits are linearly separable to the export market profits, and vice versa. However, export gains or losses arising from a sloping marginal cost curve cause this rule to fail. When marginal costs are decreasing in an individual firm's production level, some firms export even if their profit in the export market is negative, because their export gains from lower marginal costs increase profits in the domestic market. Conversely, increasing marginal costs cause some firms to forgo entry in the export market despite positive export market profits.

I find empirical evidence that sloping marginal costs curves are (i) a more important source of different economies of scale across industries, and (ii) more closely related to different properties of international business cycles across industries than nonproduction costs are. To show them, I develop an empirical framework allowing for estimating the slope of marginal cost curves. My approach relies on cost minimization and free entry condition with frictions. I first show that the estimated slopes vary considerably across industries.[3] Second, they are more strongly associated with economies of scale than nonproduction costs are. Third, in industries with decreasing marginal costs, (i) output is more volatile while imports and exports are less so, and (ii) output, imports, and exports are all more correlated with aggregate GDP than in industries with increasing marginal costs. However, I cannot find a statistically

[3]A wide range of literature have documented significant heterogeneity in economies of scale across industries, for examples, Basu and Fernald (1997), Chang and Hong (2006), and Basu et al. (2006). Chang and Hong (2006) and I use NBER CES database that tends to estimate relatively larger economies of scale than estimates based on KLEM data in Basu and Fernald (1997) and Basu et al. (2006). Their results are robust in the firm-level empirical studies such as Lee (2007). However, their results do not directly mean heterogeneity in marginal cost structures.

robust association between the industrial international business cycle and economies of scale derived from the nonproduction costs.

My empirical findings address the following question whether economies of scale arise from sloping marginal cost curves and their heterogeneity across industries can account for industrial and aggregate international business cycles. With this question in mind, I construct a two-country two-industry dynamic stochastic general equilibrium model with industry heterogeneity of cost structure along the line of the new trade open economy macroeconomic model introduced by Ghironi and Melitz (2005): monopolistic competition with endogenous entry and heterogeneous firms with an endogenous export decision. The monopolistically competitive market allows downward sloping marginal cost curves and fixed costs. The distinct feature of my model is allowing different curvature and intercept of cost curves across industries.

In terms of aggregate and industrial international business cycle properties, there are two attractive features of the model generated by the within-firm market interdependence and export gains/losses that arise from the sloping marginal cost curves. While holding the aggregate marginal cost curve flat, the benchmark model with different sloping marginal cost curves performs better than the conventional model with same flat marginal cost curves across industries to match observed strongly positive cross-country comovements of GDP and labor. Also, the model qualitatively performs well at matching the observed heterogeneous patterns of international business cycles across industries.

In my benchmark model, different slopes of the marginal cost curves endogenously generate heterogeneous properties of business cycles across industries. There are two industries, upward sloping marginal cost curve (UMC) and downward sloping marginal cost curve (DMC), in the home and foreign countries. Thus, the DMC industry faces larger economies of scale when both industries have the same nonproduction costs.[4] Suppose that a home favorable productivity shock is realized. The following two mechanisms propagate the shock. The first channel is through intensive margins by economies of scale arose from sloping marginal cost curve. An expanded domestic market increases the size of home firms, which decreases marginal costs in the DMC industry but increases marginal costs in the UMC industry. The home DMC and UMC industries face cost advantages and disadvantages, respectively. Also, the DMC industry becomes more profitable than the UMC industry. Thus, output and exports are more procyclical in the home DMC industry than in the home UMC industry. The second channel is through

[4]UMC and DMC generate diseconomies of scale and economies of scale, respectively. To focus on the marginal cost structure, I assume identical fixed costs structure across industries. For convenience, I assume decreasing and increasing marginal cost curve. A relatively negative slope of the marginal cost curve for the DMC industry is enough, for example, a constant and positive slope for DMC and UMC, respectively.

extensive export margins by export gains and losses. The DMC industry has export gains, but there are export losses in the UMC industry. The gains and losses are more important in the foreign country than in the home country because of the small domestic market and profits in the foreign country. Thus, an individual foreign firm is more willing to export in the DMC industry to enjoy large export gains. That causes industry reallocations from the UMC to DMC industry in the foreign country: more firms and exporters in the foreign DMC industry. In contrast, the home country is concentrated and exports more than before in the UMC industry. In sum, that channel generates less procyclical output and exports in the home DMC industry than in the home UMC industry, which is the opposite to the first.

I find that industrial international business cycle properties of the model crucially depend on a speed of firm entries because they determine the relative size of the propagation mechanisms in the previous paragraph. In the long run, the first channel disappears because the continuing entry of firms cause the firm size to be determined by entry costs. During a home boom, large profits in the DMC industry promote firm entries, which increase the number of firms although this increases slowly over time. A large number of firms implies the declines in individual firm's output (size), so cost advantages shrink in the home DMC industry. Thus, a substantial level of friction in firm entry – slow changes in the number of firms – makes the first channel strong relative to the second channel. Hence, the relative size of the channel hinges on the firm entry friction quantitatively. Under empirically plausible parameters, the first channel is larger than the second channel. Thus, output, exports, and imports are more procyclical in industries with decreasing marginal costs than in industries with increasing marginal costs.

Further implications of introducing different slope of marginal cost curves pertain to international business cycle comovement. Backus et al. (1992) point out international real business cycle models generate significantly low comovements that are empirically implausible.[5] A large number of studies have introduced various structures to bridge the gap between model predictions and empirical patterns.[6] This is where this paper attempts to make a contribution in international business cycle research.

While holding the aggregate marginal cost curve flat, the benchmark model reproduces stronger cross-country output correlations than a model with a homogenous flat marginal cost curve across indus-

[5] See Ambler et al. (2004) for the recent international business cycle empirical findings related to the quantity anomaly. See Rebelo (2005) for low comovements across multi-regions. Fattal-Jaef and Lopez (2014) show that the quantity anomaly is robust in new trade open macro models.

[6] For example, Heathcote and Perri (2002) and Kehoe and Perri (2002) investigate the role of capital market structures in international co-movements. Baxter and Farr (2005) and Ambler et al. (2002) introduce factor utilization and intermediate goods to generate strong positive cross-country output correlations, respectively. Head (2002) investigates impacts of national and international returns to scale on business cycle comovements. Recently, Bhattarai and Kucheryavyy (2018) study various externalities and their impacts on international comovements in a wide range of general equilibrium models.

tries does. A downward sloping marginal cost curve generates positive within-firm market interdependence between domestic and export markets. In other words, domestic and export sales are complements for individual firms, which implies more strongly positive output comovements across countries. Thus, the DMC industry contributes to mitigating the quantity anomaly. In contrast, there is negative within-firm market interdependence in UMC industry. Thus, it lowers (aggregate-level) cross-country output comovements that worsen the quantity anomaly. I calibrate parameters that the aggregate level marginal cost curve is flat, and two industries have the same size. Does the UMC industry's negative impact exactly offset the positive impact of the DMC industry on business cycle output comovements? The answer is no. Because of export gains and losses, the DMC industry's volume of trade is larger than that of the UMC industry. Thus, the positive within-firm market interdependence in DMC industry is quantitatively more massive than the UMC industry's negative within market interdependence.[7] Hence, the model generates positive aggregate level within-firm interdependence despite its aggregate marginal cost curve being flat.

This paper is organized as follows. Section 2 provides an empirical framework to study economies of scale, their sources, and industry heterogeneity. Section 3 applies the estimation methods developed in Section 2 to understand relationships between industry-level cost structures and international business cycles. In Section 4, I investigate an individual firm's problem with a sloping marginal cost curve and illustrate the analytical mechanism behind the results of the following sections. Section 5 develops a two-industry two-country dynamic stochastic general equilibrium model based on Section 4. Section 6 presents a quantitative analysis of international trade and macro dynamics. These results guide my interpretation of international business cycles associated with cost structures and their heterogeneity. The last section concludes.

[7] The theoretical prediction is also consistent with the data. The ratio of trade volume to an output of the U.S. manufacturing industries tends to increase with economies of scale and a sloping marginal cost curve coefficient (the inverse of marginal cost curve slope).

2 Empirical Framework: Cost Structure from Data with Production and Nonproduction Inputs

2.1 Firm-level Economies of Scale

Consider firms that produce goods given the production function that transforms inputs into the quantity of output y by the technology $y = Z\left[f\left(\mathbf{x}_y\right)\right]^{\alpha}$ where $\alpha > 0$. The function $f\left(\cdot\right)$ is twice continuously differentiable and homogeneous the first degree. The productivity Z is non-negative and Hicks-neutral. The vector of production inputs with the corresponding price vector $\mathbf{p}_{\mathbf{x}} = \left[p_{x,1}, \cdots, p_{x,J}\right]^{\mathrm{T}} \in \mathbb{R}_{+}^{J}$ is $\mathbf{x}_y = \left[x_{y,1}, \cdots, x_{y,J}\right]^{\mathrm{T}} \in \mathbb{R}_{+}^{J}$. Further, operating a firm requires nonproduction inputs $\mathbf{x}_{\mathrm{fc}} = \left[x_{\mathrm{fc},1}, \cdots, x_{\mathrm{fc},J}\right]^{\mathrm{T}} \in \mathbb{R}_{+}^{J}$ in amount $\mathrm{fc} = Z^{1/\alpha} f\left(\mathbf{x}_{\mathrm{fc}}\right)$.[8] The nonproduction costs $\mathbf{p}_{\mathbf{x}}{}^{\mathrm{T}}\mathbf{x}_{\mathrm{fc}}$ are mostly classified as overhead or fixed costs. $x_{y,j}$ and $x_{\mathrm{fc},j}$ are in terms of efficient unit. Thus, they have the identical price $p_{x,j}$ in the competitive factor market j. Then, a vector of the total inputs is given by $\mathbf{x} = \left[x_1, \cdots, x_J\right]^{\mathrm{T}} = \mathbf{x}_y + \mathbf{x}_{\mathrm{fc}}$.

Let tcost, pcost, and npcost be an individual firm's total, production, and nonproduction costs, respectively. The cost functions $\mathbb{R}_{+}^{J} \to \mathbb{R}_{+}$ are

$$\mathrm{tcost} = \mathrm{pcost} + \mathrm{npcost} \quad \text{where} \quad \mathrm{pcost} = \bar{c}\left(\mathbf{p}_{\mathbf{x}}, Z\right) y^{1/\alpha} \quad \text{and} \quad \mathrm{npcost} = \bar{c}\left(\mathbf{p}_{\mathbf{x}}, Z\right) \mathrm{fc}, \tag{1}$$

where the function $\bar{c}\left(\mathbf{p}_{\mathbf{x}}, Z\right)$ is twice continuously differentiable and homogenous of the first degree with respect to the input prices. In this specification, the nonproduction input j is not fixed. When its price of input j – $p_{x,j}$ – is high relative to other inputs, a firm substitutes the input j to other inputs for its operation. This specification follows Krugman (1979), Melitz (2003), and Bilbiie, Ghironi and Melitz (2012). On the other hand, Hornstein (1993), Rotemberg and Woodford (1995), Devereux, Head and Lapham (1996), and Kim (2004) assume $\mathrm{tcost} = \bar{c}\left(\mathbf{p}_{\mathbf{x}}, Z\right)\left(y + \mathrm{fc}\right)^{1/\alpha}$: $y + \mathrm{fc} = Z\left[f\left(\mathbf{x}\right)\right]^{\alpha}$. In this case, it is hard to separate nonproduction inputs from total inputs..

The inverse elasticity of production costs with respect to output is the constant as α, which determines the curvature of the total cost curve. Then, the marginal cost function satisfies $\mathrm{mc} = \left(\alpha y\right)^{-1}\mathrm{pcost}$. The

[8] Alternatively, $\mathrm{fc}' = Z\left[f\left(\mathbf{x}_{\mathrm{fc}}\right)\right]^{\alpha}$ Since fc and fc$'$ are exogenously given, the benchmark and alternative form are isomorphic.

output elasticity of marginal costs is constant as follows.

$$\frac{\partial \ln \mathrm{mc}}{\partial \ln y} = \frac{1}{\alpha} - 1 \tag{2}$$

When $\alpha = 1$, the marginal cost is constant in how much the firm produces, in other words, a flat marginal cost curve. Also, $\alpha > 1$ or $\alpha < 1$ implies the downward or upward sloping marginal cost curve, respectively. The inverse elasticity of total cost measures economies of scale (returns to scale), denoted eos.[9]

$$\mathrm{eos} = \frac{\mathrm{tcost}}{y}\frac{1}{\mathrm{mc}} = \alpha\left(1 + \frac{\mathrm{npcost}}{\mathrm{pcost}}\right) \tag{3}$$

There are two sources of economies of scale, the sloping marginal cost curve and the nonproduction costs: α and $\mathrm{npcost}/\mathrm{pcost}$.

In each period, an individual firm's cost minimizing can be represented by the following Largangian.

$$\mathcal{L}\left(\mathbf{x}_y, \mathbf{x}_{\mathrm{fc}}, \lambda_y, \lambda_{\mathrm{fc}}\right) = \mathbf{p_x}^{\mathrm{T}}\mathbf{x}_y + \mathbf{p_x}^{\mathrm{T}}\mathbf{x}_{\mathrm{fc}} + \lambda_y\left\{y - Z\left[f\left(\mathbf{x}_y\right)\right]^{\alpha}\right\} + \lambda_{\mathrm{fc}}\left\{\mathrm{fc} - Z^{1/\alpha}f\left(\mathbf{x}_{\mathrm{fc}}\right)\right\}, \tag{4}$$

where the Lagrangian multiplier is λ_y that equals to the marginal cost. The value of nonproduction is λ_{fc} that that equals to $\bar{c}\left(\mathbf{p_x}, Z\right)$.

The firm's markup denoted μ is is the ratio between its price p and marginal costs mc. The first order condition of $x_{y,j}$ is $p_{x,j} = \lambda_y\left(\partial y/\partial x_{y,j}\right) = p\left(\partial y/\partial x_{y,j}\right)/\mu$ because $\lambda_y = \mathrm{mc} = p/\mu$. Thus, I obtain

$$\mu = \left[\frac{x_{y,j}}{y}\frac{\partial y}{\partial x_{y,j}}\right]\frac{py}{p_{x,j}x_{y,j}}, \qquad \text{for } j = 1, \cdots, J, . \tag{5}$$

The Euler's homogeneous function theorem implies that

$$\mu = \alpha\frac{py}{\mathrm{pcost}} = \frac{\alpha}{1 - s_\pi}\left(1 + \frac{\mathrm{npcost}}{\mathrm{pcost}}\right) = \frac{\mathrm{eos}}{1 - s_\pi}, \tag{6}$$

where π and s_π are the profit and the profit share, respectively. Thus, the markup approaches to firm's economies of scale when its profit goes to zero.

[9] Alternatively, I can derive the relationship as follows. Let Δ be the growth rate. $\Delta y = \Delta Z + \alpha\Delta cx_y$ where Δcx_y is the cost share weighted growth rate in production inputs. Also, $\mathrm{tcost}\Delta cx \approx \mathrm{pcost}\Delta cx_y + \mathrm{npcost}\Delta cx_{\mathrm{fc}}$ where Δcx and Δcx_{fc} are the cost share weighted growth rate in total inputs and nonproduction inputs, respectively. Δcx_{fc} is independent of output growth Δy in the firm level. Thus, I obtain that $\frac{\partial \Delta y}{\partial \Delta cx} = \alpha\left(1 + \mathrm{npcost}/\mathrm{pcost}\right)$.

2.2 Industry-level Economies of Scale: Role of Entries

Endogenous entry yields a difference between industry- and firm-level production functions because the changes in the number of firms endogenize the nonproduction cost in the (aggregated) industry level.

Consider monopolistic competition. Then, the profit excluding nonproduction costs is $(1-\alpha/\mu)\,py$ when a firm produces. The condition for the non-corner solution is $\mu > \alpha$. $\mu < \alpha$ implies a natural monopoly. $\mu = 1$ and $\alpha \leq 1$ in a perfectly competitive market.

The industry output (value of shipments) is $Y = \sum py$. The number of firms in the industry is denoted by N. Then, the identical firms imply that $Y = Npy = N^{\mu}y$ because $p = N^{\mu-1}$. The individual and industry profits are π and $\Pi = N\pi$, respectively. The industry total, production, and nonproduction inputs are $\mathbf{X} = N\mathbf{x}$, $\mathbf{X}_y = N\mathbf{x}_y$, and $\mathbf{X}_{\text{fc}} = N\mathbf{x}_{\text{fc}}$, respectively.

The entry condition depends on a degree of competition (the number of existing firms or varieties). In line with this, I introduce the wedge or friction in the firm entry denoted by ε. The following modified entry condition is

$$1 = \left(1 - \frac{S_\Pi}{1-\alpha/\mu}\right)^{\varepsilon}\left(\frac{N}{N_0}\right)^{1-\varepsilon}, \tag{7}$$

where $S_\Pi = \Pi/Y$ is the profit share. The share is constrained by $1-\alpha/\mu$ representing the profit divided by the production costs. The parameter $\varepsilon \geq 0$ represents the wedge or friction in the firm entry. If $\varepsilon = 1$, the firm entry is fully flexible. The above condition is equal to the traditional free entry condition (or zero profit condition: $S_\Pi = 0$), which determines the number of firms. If $\varepsilon = 0$, the number of firms is fixed as the arbitrary number N_0.

The (industry) aggregate production and nonproduction costs are $\mathrm{PCOST} = N\mathrm{pcost} = \mathbf{p_x}^{\mathrm{T}}\mathbf{X}_y$ and $\mathrm{NPCOST} = N\mathrm{npcost} = \mathbf{p_x}^{\mathrm{T}}\mathbf{X}_{\text{fc}}$, respectively. Equation (6) implies $S_\Pi = (1-\alpha)\,\mathrm{TCOST}/\mathrm{PCOST}$. Thus, I can rewrite the modified entry condition as follows.

$$\left(\frac{\mu}{\alpha} - 1\right)\frac{\mathrm{PCOST}}{\mathrm{NPCOST}} = \left(\frac{N}{N_0}\right)^{1/\varepsilon-1}, \tag{8}$$

where at the aggregate industry level, the nonproduction costs are not anymore fixed because of the endogenously determined number of firms.

The industry output is $Y = Npy = N^{\mu-\alpha}Z\left[f\left(\mathbf{X}_y\right)\right]^{\alpha}$. Since $\left(\frac{\mu}{\alpha}-1\right)\left[f\left(\mathbf{X}_y\right)/f\left(\mathbf{X}_{\text{fc}}\right)\right] = \left(N/N_0\right)^{1/\varepsilon-1}$, the output is given by

$$Y = Npy = \tilde{Z}_\beta \left[f\left(\mathbf{X}_y\right) \right]^{\alpha + \frac{\varepsilon}{1-\varepsilon}(\mu - \alpha)} \left[f\left(\mathbf{X}_{\text{fc}}\right) \right]^{-\frac{\varepsilon}{1-\varepsilon}(\mu-\alpha)}, \tag{9}$$

where $\tilde{Z}_\beta = ZN_0^{-\frac{\varepsilon}{1-\varepsilon}(\mu-\alpha)}$. Thus, the marginal output elasticity of production inputs is $\alpha + \frac{\varepsilon}{1-\varepsilon}(\mu - \alpha)$. Equivalently, I obtain

$$Y = \tilde{Z}_{\gamma_y} \left[f\left(\mathbf{X}_y\right) \right]^{\varepsilon\mu + (1-\varepsilon)\alpha}, \tag{10}$$

where $\tilde{Z}_{\gamma_y} = \left[(\mu/\alpha - 1)/\text{fc} \right]^{\varepsilon(\mu-\alpha)} Z^{1+\varepsilon(\mu-\alpha)/\alpha} N_0^{\mu-\alpha}$. The output elasticity of production inputs is the combination of returns to scale and markups.

Suppose that $f(\cdot)$ is a Cobb-Douglas function. The growth rate of output is denoted by ΔY that can be represented by the output elasticity multiplied by the cost share growth rate of total, production, nonproduction inputs ($\Delta f(\mathbf{X})$, $\Delta f(\mathbf{X}_y)$, and $\Delta f(\mathbf{X}_{\text{fc}})$, respectively) as follows.

$$\Delta Y = \Delta \tilde{Z}_\beta + \beta_y \Delta f\left(\mathbf{X}_y\right) + \beta_{\text{fc}} \Delta f\left(\mathbf{X}_{\text{fc}}\right) \tag{11}$$

$$\Delta Y = \Delta \tilde{Z}_{\gamma_y} + \gamma_y \Delta f\left(\mathbf{X}_y\right) \tag{12}$$

$$\Delta Y = \Delta \tilde{Z}_\gamma + \gamma \Delta f\left(\mathbf{X}\right), \tag{13}$$

where $\beta_y = \alpha + \frac{\varepsilon}{1-\varepsilon}(\mu - \alpha)$, $\beta_{\text{fc}} = \alpha - \beta_y - \frac{\varepsilon}{1-\varepsilon}(\mu - \alpha)$, and $\gamma_y = \varepsilon\mu + (1-\varepsilon)\alpha$. Since $\text{TCOST}\Delta f(\mathbf{X}) \approx \text{PCOST}\Delta f(\mathbf{X}_y) + \text{NPCOST}\Delta f(\mathbf{X}_{\text{fc}})$, the output elasticity of total costs is

$$\text{EOS} = \gamma = \frac{\text{TCOST}}{\text{PCOST} + \varepsilon\text{NPCOST}} \left[\varepsilon\mu + (1-\varepsilon)\alpha \right], \tag{14}$$

which is a degree of economies of scale at the (aggregated) industry-level. The nonproduction costs and $\varepsilon \neq 1$ break the equality of the markup and economies of scale. If $\varepsilon = 1$, the entry condition implies that the degree of economies of scale equals the markup as Rotemberg and Woodford (1995) and Basu and Fernald (1997) point out. In the case, $\mu \geq 1$ implies that the industry-level returns to scale must be either constant or increasing, which is inconsistent with the empirical findings of industry level estimation. However, my empirical framework suggests that a significant amount of the wedge ($\varepsilon > 0$) and the small output elasticity of production input ($\alpha < 1$) can generate significantly diminishing returns (diseconomies). Furthermore, if the number of firms is fixed, $\varepsilon = 0$, the relationship among EOS, α and

$\mathrm{NPCOST}/\mathrm{NPCOST}$ equals the relationship in the firm level as in Equation (3).

2.3 Data-consistent vs Welfare-based Price Indices

As discussed in Ghironi and Melitz (2005), real variables in data are based on consumer price index (CPI), and they do not count variety effects. Thus, they define the data-consistent (aggregated) industry output as $Y_R = N^{1-\mu}Y$. Then, I obtain that

$$\Delta Y_R = \Delta \tilde{Z}_{\beta,R} + \beta_{y,R}\Delta f\left(\mathbf{X}_y\right) + \beta_{\text{fc},R}\Delta f\left(\mathbf{X}_{\text{fc}}\right) \tag{15}$$

$$\Delta Y_R = \Delta \tilde{Z}_{\gamma_y,R} + \gamma_{y,R}\Delta f\left(\mathbf{X}_y\right) \tag{16}$$

$$\Delta Y_R = \Delta \tilde{Z}_{\gamma,R} + \gamma_R\Delta f\left(\mathbf{X}\right). \tag{17}$$

The coefficients are

$$\beta_{y,R} = \alpha + \frac{\varepsilon}{1-\varepsilon}\left(1-\alpha\right) \quad \text{and} \quad \beta_{\text{fc},R} = \alpha - \beta_{y,R} \tag{18}$$

$$\gamma_{y,R} = \varepsilon + \left(1-\varepsilon\right)\alpha \quad \text{and} \quad \gamma_R = \frac{\mathrm{TCOST}}{\mathrm{PCOST}+\varepsilon\mathrm{NPCOST}}\gamma_{y,R}. \tag{19}$$

The above result implies that a degree of economies of scale with CPI-based output measure depends on the marginal cost curve (inverse elasticity of production costs) and on the nonproduction costs as follows.

$$\mathrm{EOS}_R = \frac{\mathrm{TCOST}}{\mathrm{PCOST}+\varepsilon\mathrm{NPCOST}}\left[\varepsilon + \left(1-\varepsilon\right)\alpha\right] \tag{20}$$

As EOS, EOS_R equals to the elasticity of variable cost α without the firm entry (fixed number of firms: $\varepsilon = 0$). If $\varepsilon = 1$, then the observed industry-level economies of scale is close to one. Without the variety effect, frictionless free entry yields no aggregate-level scale effect. A sharply upward sloping marginal cost curve (small $\alpha < 1$) with $\varepsilon \in (0,1)$ generate diseconomies of scale.

Because $\mu \geq 1$ and $\varepsilon \geq 0$, the CPI-based measure of economies of scale is smaller than the welfare-based measure of economies of scale. The difference between welfare- and CPI-based economies of scale measurements converges to zero in the fixed number of firms (no firm entry).

$$\mathrm{EOS} - \mathrm{EOS}_R = \frac{\mathrm{TCOST}}{\mathrm{PCOST}+\varepsilon\mathrm{NPCOST}}\varepsilon\left(\mu-1\right) \to 0 \quad \text{as } \varepsilon \to 0$$

Moreover, the perfectly competitive market yields $\text{EOS} = \text{EOS}_R$, because $\mu = 1$ implies perfect substitutes across products, in other words, homogenous products. Since people do not care about varieties, the average price (CPI) is welfare-consistent.

2.4 Methodology

This section describes estimation of the cost structure. Section 3 will be applying the estimation method using data. As the benchmark, I use Equation (15) which permits estimation of many parameters representing industry level cost structures. As the first step, I estimate

$$\Delta Y_R = \text{constant} + \beta_{y,R}\Delta f\left(\mathbf{X}_y\right) + \beta_{\text{fc},R}\Delta f\left(\mathbf{X}_{\text{fc}}\right) + \epsilon_\beta. \tag{21}$$

Then, I obtain that $\alpha = \beta_{y,R} + \beta_{\text{fc},R}$. Additionally, $\varepsilon = \frac{\beta_{\text{fc},R}}{\beta_{y,R}+2\beta_{\text{fc},R}-1}$. I can calculated the implied output elasticity of production and total inputs, $\gamma_{y,R}$ and γ_R, respectively.

Alternatively, combining the regressions based on the following two equations allows for estimating α. As in the previous literature, I estimate

$$\Delta Y_R = \text{constant} + \gamma_R \Delta f\left(\mathbf{X}\right) + \epsilon_\gamma \tag{22}$$

which gives the measure for economies of scale. Also, I consider the following.

$$\Delta Y_R = \text{constant} + \gamma_{y,R}\Delta f\left(\mathbf{X}_y\right) + \epsilon_{\gamma_y}, \tag{23}$$

In each regression, I cannot estimate the sloping marginal cost curve coefficient α and the wedges in the firm entry ε. The ratio of two estimators is given by

$$\frac{\gamma_R}{\gamma_{y,R}} = \frac{1 + \text{NPCOST}/\text{PCOST}}{1 + \varepsilon\text{NPCOST}/\text{PCOST}}. \tag{24}$$

If $\varepsilon \in [0, 1)$, the ratio is greater than one because the total costs are less flexible than the production costs due to nonproduction inputs. Thus, a large amount of nonproduction inputs increases the ratio. When the firm entry is excessively flexible, $\varepsilon > 1$, the ratio can be smaller than one, which case is rarely observed in my data. Equation (24) is the alternative method for calculating ε because TCOST, PCOST, and NPCOST are directly observable. Finally, for given ε I obtain the implied α by using

$\gamma_{y,R} = \varepsilon + (1 - \varepsilon)\,\alpha.$

3 Cost Structure and Industrial International Business Cycles

This section documents the stylized facts of cost (or production) structure and the international business cycle of U.S. manufacturing industries. First, I describe cost structure heterogeneity across manufacturing industries. Second, I illustrate how international business cycle fluctuations vary with a cost structure. My empirical business cycle research is based on annual data.

3.1 Cost Structure

3.1.1 Data and Estimation

The six-digit North American Industry Classification System (NAICS) industry data used in this study are taken from the NBER-CES Manufacturing Industry Database (annual from 1958 through 2011).[10] These data provide each industry's value of the shipments, value-added, inputs (labor, capital, and materials), and their deflators. The major advantage is that these data collect production and nonproduction labor inputs and costs. Appendix A illustrates how to construct the cost share-weighted growth rate in total, production, and nonproduction inputs, and it also describes the details of data sources, sample construction, variables, and measurements.

Figure 1 displays correlations among output, cost share-weighted production and nonproduction inputs for the narrowly defined industry level. My specification predicts that the production and nonproduction input growth rates are perfectly correlated when firm entry is fully flexible (no friction: $\varepsilon = 1$). Oppositely, the fixed number of firms (no entry: $\varepsilon = 0$) implies that they are orthogonal: zero correlation. Figure 1 shows the descriptive evidence of heterogeneous degree of entry frictions across industries. The unweighted and weighted median of correlations are 0.472 and 0.560 in the short run (1 year), respectively. In the long run (10 year), they are 0.808 and 0.831, respectively.[11]

To estimate an industry-level production function, I consider both instrumented and uninstrumented regressions by using Generalized Method of Moments (GMM) estimator.[12] Production function esti-

[10] Link to `http://www.nber.org/nberces/`. The six-digit NAICS corresponds to the four-digit Standard Industrial Classification (SIC).

[11] See Table A1 in Appendix E for the details.

[12] I calculate standard errors with heteroskedasticity and autocorrelation consistent (HAC) estimator. HAC weight matrix using the specified kernel, and the lag order is selected using Newey and West's (1994) optimal lag-selection algorithm.

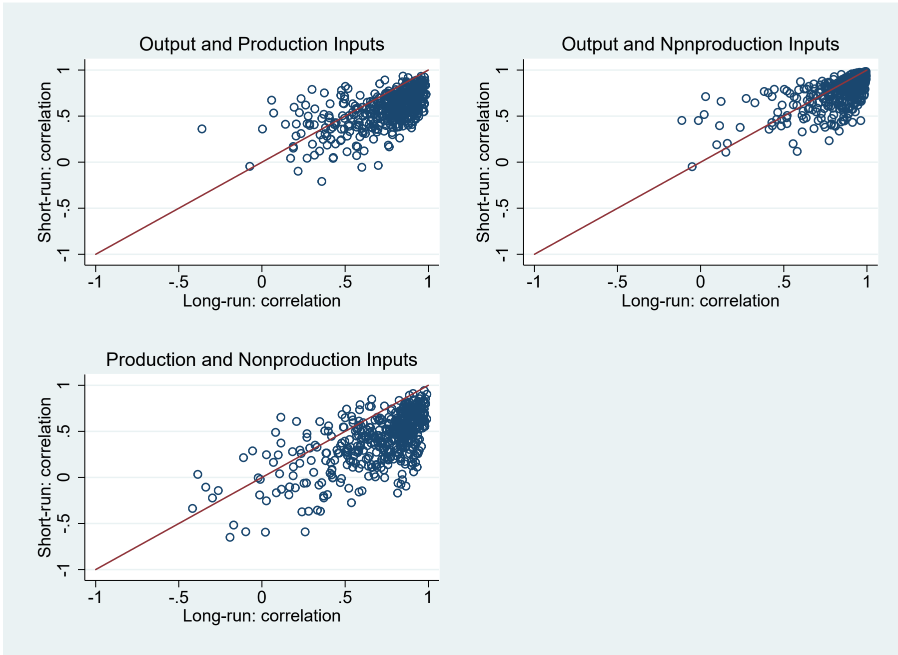

Figure 1: Correlations: Short- and Long-run Growth Rates of Outputs and Cost Share-weighted Inputs

Notes: The red lines are the 45 degree line. The number of observations is 467 industries. The short-run and long-run growth rates are 1 and 10 years, respectively.

mates obtained by the uninstrumented method are biased by the association between productivity and input demands. To control for endogeneity, demand-side instruments such as oil price shocks, the president's party, government defense spending, and monetary policy shocks are widely used. (See Appendix B for the details.) According to Basu and Fernald (1997), the demand-side instruments are not completely exogenous and are weakly correlated to regressors. In this case, Nelson and Startz (1990) point out that IV estimates can be more biased than ordinary least squares estimates. Thus, I focus on the uninstrumented results. Also, I am interested in the cost-structure heterogeneity across industries. Thus, uninstrumented GMM estimation serves the primary purpose of this study.

3.1.2 Estimation Result: Cost Structure

My data covers 467 six-digit NAICS manufacturing industries. Theoretically, economies of scale, output elasticity of production inputs (marginal cost coefficient), and firm entry wedge have to be non-negative. Thus, I dropped the estimates when they have negative values. Their contribution in the economy is negligible. For example, the estimated α with the benchmark method is one industry: NAICS 311920

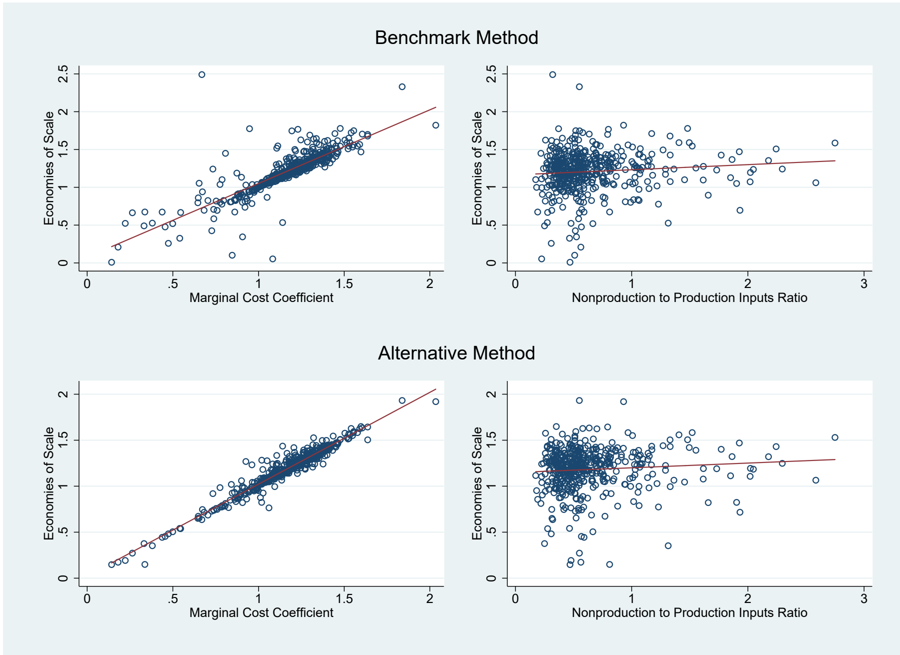

Figure 2: Estimated Economies of Scale, Sloping Marginal Costs, and Nonproduction Costs

Notes: The red lines are the fitted values by using OLS regressions.

— coffee and tea manufacturing industry. Thus, allowing negative estimates has no significant impact on all final results. See Appendix C for the details of the dropping procedure.[13]

The data show that the important pattern is the wide range of economies of scale and marginal costs rather than it of nonproduction costs. Figure 2 illustrates the estimated cost structures for each industry, which shows significant heterogeneity of cost structure across narrowly defined industries. Economies of scale have a weaker positive relationship to nonproduction input ratios than to the marginal cost coefficients. These patterns imply that sloping marginal cost curves are important to understanding economies of scale.

I define two groups of industries, LEOS and SEOS. An industry in LEOS exhibits economies of scale at 1 % significance level for each regression method (instrumented vs uninstrumented $\times$ benchmark vs alternative). The SEOS industries form the remainder. Table reports the lists of six-digit NAICS industries for the four methods.

Table 1 reports the estimated cost structures for each industry based on the benchmark and alternative methods. Even though my alternative estimation follows Basu and Fernald (1997), Table 1 indicates sta-

[13] See Table TA2 for the dropped estimates.

Table 1: Estimated Cost Structures

	Total			SEOS			LEOS		
	Mean	Median	Obs.	Mean	Median	Obs.	Mean	Median	Obs.
Panel A: Uninstrumented GMM									
Benchmark: Equation (21)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.692	0.549	467	0.709	0.567	233	0.674	0.535	228
γ_R	1.124	1.160	461	0.962	0.995	233	1.381	1.355	228
$\gamma_{y,R}$	0.989	1.058	458	0.889	1.005	225	1.145	1.137	228
α	1.068	1.113	466	0.923	1.017	233	1.303	1.285	228
Alternative: Equations (22) and (23)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.692	0.549	467	0.751	0.590	216	0.625	0.516	250
γ_R	1.101	1.194	466	0.903	0.987	216	1.325	1.297	250
$\gamma_{y,R}$	0.901	0.965	466	0.729	0.755	216	1.095	1.125	250
α	1.177	1.051	401	0.868	0.717	168	1.436	1.266	233
Panel B: Instrumented GMM									
Benchmark: Equation (21)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.692	0.549	467	0.759	0.590	247	0.626	0.519	200
γ_R	1.347	1.237	447	1.259	1.029	247	1.500	1.390	200
$\gamma_{y,R}$	1.170	1.084	450	1.038	1.002	241	1.217	1.166	200
α	1.135	1.157	461	0.991	1.031	247	1.401	1.347	200
Alternative: Equations (22) and (23)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.692	0.549	467	0.799	0.590	174	0.622	0.519	290
γ_R	1.171	1.265	464	0.845	0.926	174	1.387	1.350	290
$\gamma_{y,R}$	1.006	1.076	463	0.763	0.735	172	1.171	1.159	290
α	1.280	1.254	385	0.943	0.800	135	1.456	1.339	250

Notes: An industry in LEOS exhibits economies of scale at 1 % significance level. The SEOS industries form the remainder. In Panel B, I use GMM with the demand side instruments to estimate cost structure. (See Appendix B for the details.) All results are weighted by using the over-time average of industry's fraction of unfiltered nominal value of shipments: $\text{weight}^s_{PY} = (1/T)[\sum_t (P^s_t Y^s_t / \sum_{s'} P^{s'}_t Y^{s'}_t)]$. I report the weighted results in Table A2. See Table TA2 for the results for each six-digit NAICS industry.

tistically significant economies of scale in overall manufacturing industries, which is contrary to the findings in Basu and Fernald (1997) and Basu et al. (2006) based on two-digit SIC industry level estimations. (See Table A2 for the unweighted results.) The result is robust on instrumented and un-instrumented regressions. The reason for the difference between my results and those of Basu and Fernald (1997) and Basu et al. (2006) is that the NBER CES database tends to yield larger economies of scale estimates than the KLEM data does in Basu and Fernald (1997) and Basu et al. (2006).[14]

[14] See Basu et al. (2006) and Chang and Hong (2006) for the difference between results based on KLEM and NBER CES database. They report estimated returns to scale and utilization parameters for two-digit manufacturing industries: Table 1 in Basu et al. (2006) and Table 5 in Chang and Hong (2006). Chang and Hong (2006) follow Basu et al. (2006)'s estimation method, but their estimates tend to be larger than estimates in Basu et al. (2006).

Table 2: Estimation Results: Correlation among Cost Structures

	Panel A: Uninstrumented GMM						Panel B: Instrumented GMM					
	Benchmark			Alternative			Benchmark			Alternative		
	γ_R	$\gamma_{y,R}$	α	γ_R	$\gamma_{y,R}$	α	γ_R	$\gamma_{y,R}$	α	γ_R	$\gamma_{y,R}$	α
Benchmark: Equation (21)												
$\gamma_{y,R}$	0.794	1.000					0.783	1.000				
	(453)	(458)					(441)	(450)				
α	0.898	0.788	1.000				0.785	0.798	1.000			
	(461)	(458)	(466)				(447)	(450)	(461)			
Alternative: Equations (22) and (23)												
γ_R	0.885	0.763	0.946	1.000			0.686	0.668	0.815	1.000		
	(461)	(458)	(466)	(466)			(447)	(450)	(461)	(464)		
$\gamma_{y,R}$	0.720	0.624	0.684	0.715	1.000		0.563	0.526	0.647	0.737	1.000	
	(461)	(458)	(466)	(466)	(466)		(447)	(450)	(460)	(462)	(463)	
α	0.673	0.576	0.635	0.665	0.922	1.000	0.458	0.426	0.494	0.598	0.808	1.000
	(399)	(396)	(401)	(401)	(401)	(401)	(374)	(379)	(383)	(385)	(385)	(385)
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.112	0.023	0.146	0.106	-0.229	-0.245	-0.024	-0.097	0.008	-0.017	-0.218	-0.209
	(461)	(458)	(466)	(466)	(466)	(401)	(447)	(450)	(461)	(464)	(463)	(385)

Notes: I report Spearman's rank correlation coefficients rather than Pearson correlation coefficients. Thus, the results are invariant to positive monotonic transformation of the variables. The correlations are among the estimates with non-negative values. The numbers of observations are in parentheses.

In Table 1, LEOS industries do not tend to have a higher ratio of nonproduction input to production input than SEOS industries even though LEOS industries exhibit larger economies of scale than SEOS industries. However, marginal cost coefficients of LEOS industries are greater than SEOS industries robustly, which implies that marginal costs are quantitatively more important than nonproduction costs as sources of economies of scale.[15] The Spearman's rank correlation coefficients in Table 2 support these results. The marginal coefficients are strongly correlated with economies of scale, but, the nonproduction to production input ratios are not.

3.2 The International Business Cycle of the U.S. Manufacturers

To investigate the international business cycle of the U.S. Manufacturers, I use Hodrick and Prescott (1997)'s high-pass filtered cyclical components of logarithmic annual output, export, and import data. Also, I consider the HP filtered with a various range of smoothing parameter, the growth rate of the variable minus its average. The results are robust to the choice of them.[16] NBER-CES manufacturing industry database does not provide international trade flows. I collect them from Schott (2008)'s annual

[15]These patterns hold after controlling for durables and non-durables.

[16]I set the smoothing parameter to be 6.25, 100, and 400 that are widely used for annual frequency business cycle studies.

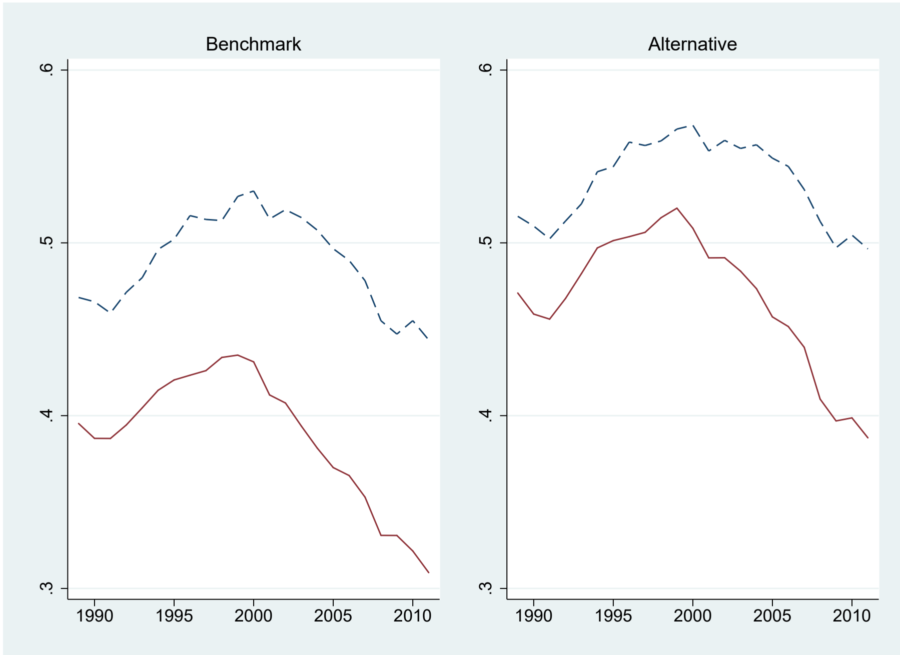

Figure 3: Output and Trade Shares of LEOS

Notes: The red lines and the blue dashed lines are the output and trade (exports plus imports) share of LEOS industries in the total, respectively.

data that is available from 1989. See Appendix A for the details.

3.2.1 Descriptive Evidence: International Business Cycles Vary with Industry Cost Structure

To show how international business cycles vary with economies of scale, I classify industries into two-by-two categories. First, I consider SEOS and LEOS industries by using estimated EOS by benchmark OLS as in Section 3.1.2. LEOS and SEOS industries represent industries with large and small economies of scale, respectively. Second, I consider durable and nondurable industries.[17] A wide range of empirical research has reported that durables exhibit larger returns to scale than nondurables, which is consistent with my results. Also, durables are more pocyclical than nondurables.[18] For these reasons, I introduce the two-by-two classification to check counterfactuals. Roles of economies of scale do not depend on the type of goods industries produce.

LEOS is more trade intensive than SEOS because economies of scale motivate export by decreasing average costs. Define the output and trade share of each group as follows. Let x_t^s be the nominal value

[17]See Table TA1 for the NAICS code for durables and nondurables.
[18]See Stock and Watson (1999) for the literature review.

Table 3: Summary Statistics: Volatility

		Total			SEOS			LEOS		
		output	export	import	output	export	import	output	export	import
Panel A: HP-filtered series										
Nondurable	mean	4.758	2.218	2.231	4.254	2.417	2.452	6.782	1.349	1.390
	median	4.309	1.777	1.748	3.733	1.836	1.840	6.063	1.273	1.152
	obs.	194	149	149	120	97	97	69	48	48
Durable	mean	8.015	1.797	1.844	7.291	1.998	2.203	8.648	1.641	1.563
	median	7.660	1.305	1.488	7.346	1.394	1.699	7.882	1.200	1.350
	obs.	273	228	228	113	96	96	159	131	131
Total	mean	6.477	1.998	2.029	5.503	2.257	2.357	8.173	1.576	1.525
	median	6.070	1.505	1.617	5.303	1.763	1.748	7.658	1.200	1.276
	obs.	467	377	377	233	193	193	228	179	179
Panel B: Growth rate										
Nondurable	mean	8.041	2.369	2.227	7.147	2.601	2.473	11.609	1.408	1.262
	median	7.605	1.738	1.731	6.278	2.444	1.978	10.784	1.238	1.127
Durable	mean	12.615	1.886	1.869	11.535	2.086	2.191	13.561	1.731	1.619
	median	11.938	1.313	1.501	10.942	1.401	1.628	12.486	1.260	1.371
Total	mean	10.456	2.117	2.040	8.951	2.404	2.365	13.064	1.659	1.539
	median	9.639	1.489	1.554	8.676	1.778	1.739	12.463	1.257	1.276

Notes: The numbers of industries in Panel B are equal to the numbers in Panel A. All results are weighted by using the over-time average output share of industry defined in Equation (25). Unweighted results are reported in Appendix E (Table A3). Volatilities of output are measured by standard deviations in terms of percentage. Volatilities of imports and exports are measured by standard deviations relative to output.

of shipments or the trade volume (exports plus imports) in industry s in year t. Then, for group = SEOS and LEOS,

$$\text{Share of group} = \frac{1}{T}\sum_{t}\sum_{s\in\text{group}} \text{weight}^{s}_{x,t}, \tag{25}$$

where $\text{weight}^{s}_{x,t} = P^s_t x^s_t / (\sum_{s'\in\text{Total}} P^{s'}_t x^{s'}_t)$. Figure 3 illustrates that the trade shares are larger than the output shares. On average, the output shares of SEOS and LEOS are 0.615 and 0.385, respectively. But, the trade shares of SEOS and LEOS (based on the benchmark method) are 0.510 and 0.490, respectively.[19] Thus, LEOS industries are more trade intensive than SEOS industries. After 2000, LEOS industries have shrunk in terms of both output and trade. However, the key pattern does not change over time. The trade shares of LEOS industries are consistently larger than their output shares.

[19]By using the alternative method, the output shares of SEOS and LEOS are 0.464 and 0.536, respectively. But, the trade shares of SEOS and LEOS are 0.531 and 0.469, respectively.

Table 4: Summary Statistics: Cylicality

		Total			SEOS			LEOS		
		output	export	import	output	export	import	output	export	import
		Panel A: HP-filtered series								
Nondurable	mean	0.348	0.158	0.382	0.323	0.092	0.337	0.459	0.367	0.531
	median	0.306	0.171	0.427	0.227	0.124	0.260	0.470	0.395	0.505
	obs.	194	149	149	120	97	97	69	48	48
Durable	mean	0.554	0.393	0.549	0.486	0.289	0.507	0.613	0.474	0.581
	median	0.652	0.445	0.612	0.554	0.283	0.583	0.681	0.541	0.649
	obs.	273	228	228	113	96	96	159	131	131
Total	mean	0.512	0.311	0.530	0.390	0.167	0.402	0.574	0.451	0.570
	median	0.512	0.311	0.530	0.404	0.171	0.428	0.655	0.521	0.625
	obs.	467	377	377	233	193	193	228	179	179
		Panel B: Growth rate								
Nondurable	mean	0.360	0.156	0.369	0.334	0.091	0.319	0.469	0.366	0.549
	median	0.342	0.186	0.334	0.332	0.163	0.226	0.476	0.392	0.544
Durable	mean	0.532	0.363	0.523	0.467	0.256	0.470	0.588	0.448	0.565
	median	0.615	0.372	0.572	0.519	0.210	0.539	0.641	0.501	0.608
Total	mean	0.451	0.264	0.450	0.388	0.154	0.376	0.558	0.430	0.561
	median	0.501	0.293	0.512	0.369	0.163	0.376	0.635	0.473	0.601

Notes: The numbers of industries in Panel B is equals to the numbers in Panel A. All results are weighted by using the over-time average output share of industry defined in Equation (25). Unweighted results are reported in Appendix E (Table A4). Cyclicalities are correlations to the aggregated business cycle component of outputs that is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year.

Tables 3 and 4 summarize the U.S. industry-level volatility and cyclicality of output, exports, and imports for each group and in total. There are 273 durable and 194 non-durable industries, of which durables have larger economies of scale than non-durables. Among 228 LEOS industries, 69 are non-durable and 159 are durable. Volatilities of output are measured by standard deviations of the detrended outputs from 1958 to 2011 in terms of percentage. Volatilities of trade flows are measured by standard deviations relative to standard deviations of industry output from 1989 to 2011.[20] Cyclicalities are measured by Pearson correlation coefficients to aggregated cyclical deviations of real outputs of manufacturing industries. Alternatively, I use Pearson correlation to cyclical deviations of real GDP.[21] As in

[20]NBER CES data cover 1958 – 2011, but exports and imports data by Schott (2008) (and his update) start in 1989. When I calculate relative standard deviations of trade flows, I use standard deviations of the cyclical deviations of outputs with the same sample periods (1989 – 2011).

[21]I measure cyclicalities of output by using the data from 1958 – 2011. When I calculate cyclicalities of exports and imports, I use filtered output or real GDP in the sample periods 1989 – 2011 because my trade flow data start in 1989. Different sample periods generate different HP filtered output and real GDP series. However, the difference from choosing the periods has no significant impact on my all results.

the previous empirical literature, the trade flows are more volatile than outputs. Exports and imports are both procyclical, although imports are more strongly so.

The differences between SEOS and LEOS industries give a rough indication of how industry macro and trade dynamics vary with economies of scale. LEOS industries tend to have more volatile output but less volatile export and import flows than do SEOS industries. Output, export, and import are more strongly correlated to aggregate GDP in LEOS industries than in SEOS industries. After considering durables and non-durables, these patterns hold generally in Tables 3 and 4. Moreover, these patterns are robust on the estimation methods.

3.2.2 Methodology

For more accurate investigation of the statistical relation between industrial international business cycles and industry cost structures, I consider regressions as follows. To investigate the net impacts of each source of economies of scale – sloping marginal costs and nonproduction costs –, I consider the following relations.[22] For s industry,

$$\ln \mathrm{EOS}^s \approx \ln \alpha^s + \ln \left(1 + \frac{\mathrm{PCOST}^s}{\mathrm{NPCOST}^s}\right). \tag{26}$$

I define economies of scale derived from marginal and nonproduction costs by $\mathrm{EOS}^s_{MC} = \ln \alpha^s$ and $\mathrm{EOS}^s_{NC} = \ln\left(1 + \mathrm{NPCOST}^s/\mathrm{PCOST}^s\right)$, respectively. Let bc^s_y, bc^s_{ex}, and bc^s_{im} be a measure of volatility or cyclicality for output, exports, and imports, respectively. The three regression equations are

$$\mathrm{bc}^s_r = \left(\mathbf{x}^s\right)^{\mathrm{T}} \mathbf{b}_r + \epsilon^s_r \quad \text{where } r = y, ex, im. \tag{27}$$

The vector of coefficients corresponding to independent variables $\mathbf{x}^s$ is $\mathbf{b}_r$. I use the seemingly unrelated regression equations (SURE) method with three equations for each industry rather than the equation by equation estimations. Breusch-Pagan test of independent equations is rejected at the 1 $\%$ significant level.

As regressors, their vector is denoted by $\mathbf{b}_r$, I consider the cost structure parameters: EOS^s_{MC}, EOS^s_{NC}, and ε^s. Also, I control for goods classifications. First, the durable dummy variable is one

[22]There are two ways to obtain the decomposition of economies of scale into marginal and nonproduction costs. First, in Equation (6), the firm level economies of scale with tiny profits. Second, the industry level economies of scale ignoring the entry friction effects in Equation (20).

($D^s = 1$) if s industry produces durable goods. It is zero ($D^s = 0$) if s is a non-durable industry. I divide manufacturing industries into non-durables.[23] Second, I use the ratio of material costs to the value of shipments, denoted by θ_m^s, as an indicator of intermediate and final goods industries. In the following sections, I focus on coefficient estimates on economies of scale derived from the sloping marginal cost curve and the nonproduction costs. I leave these issues related to coefficient estimates on other regressors.

As I mentioned in Section 3.2.1, the cost structure characteristics of durable and nondurable industries are significantly different. It is possible that the impacts of industry characteristics on the business cycle patterns are not identical. Thus, the regression coefficients would be different. To test this hypothesis, I use the product of the durable dummy and each regressor.

3.2.3 Estimation Results: International Business Cycles

Tables 5 – 7 and 8 – 10 show significant evidence that industry cost-side characteristics play a fundamental role in the volatility and cyclicality of international trade and macroeconomic flows, respectively. All regression results are weighted by the industry size, which is measured by the value of shipments. In Columns (1) – (4), the volatility and cyclicality are measured based on detrended series with HP filter. In Columns (5) – (8), I use the log difference time series (growth rates). The regression in Columns (1) contains only the cost structure variables: EOS_{MC}, EOS_{NC}, and $\ln \varepsilon$. In Column (2), I add the share of material costs: $\ln \theta_m$. The regressions in Columns (3) and (4) control for durability of products in addition to the regressions in Columns (1) and (2), respectively.

Tables 5, 6, and 7 present regressions of a volatility (a standard deviation of industry output and trade flows's standard deviations relative to output) on economies of scale from marginal cost coefficient and nonproduction costs. In Table 5, the estimated $\hat{b}_1$ in all columns are positive at the 1% significance level. Industries with larger economies of scale derived from a sloping marginal cost curve tend to have more volatile output than smaller industries with large economies of scale derived from a sloping marginal cost curve. All columns in Tables 6 and 7 report that $\hat{b}_1$ is negative at the 5% significance level. Exports and imports are less volatile when industries have large economies of scale from marginal costs. My benchmark regression reported in Column (2) indicates that a one percent increase in economies of scale derived from marginal costs is associated with a 0.73 increase in the industry's standard deviation ($\%$) of output. Further, a one percent increase in economies of scale derived from marginal costs is

[23] See Table TA1 for the NAICS code for durables and nondurables.

Table 5: Regression Results: Volatility of Output and Market Structures

	Log Percent SD of HP-filtered Series				Log Percent SD of Growth Rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	0.762***	0.730***	0.497***	0.465***	0.710***	0.703***	0.501***	0.461***
	(0.079)	(0.069)	(0.084)	(0.083)	(0.073)	(0.068)	(0.083)	(0.081)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			0.473***	0.581***			0.384***	0.516***
			(0.135)	(0.137)			(0.132)	(0.133)
b_2 : EOS_{NC}	-0.124	0.177**	-0.313**	-0.378***	-0.032	0.224***	-0.284**	-0.393***
	(0.077)	(0.073)	(0.124)	(0.128)	(0.071)	(0.072)	(0.122)	(0.125)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			0.611***	0.732***			0.645***	0.847***
			(0.138)	(0.153)			(0.136)	(0.150)
b_3 : $\ln \varepsilon$	-0.092***	-0.092***	-0.077***	-0.139***	-0.081***	-0.083***	-0.068***	-0.118***
	(0.032)	(0.026)	(0.025)	(0.037)	(0.029)	(0.026)	(0.025)	(0.036)
$b_{3,D}$: $D \times \ln \varepsilon$				0.103**				0.073
				(0.050)				(0.049)
b_4 : $\ln \theta_m$		0.684***	0.696***	0.472***		0.581***	0.587***	0.287***
		(0.080)	(0.077)	(0.109)		(0.078)	(0.076)	(0.107)
$b_{4,D}$: $D \times \ln \theta_m$				0.398***				0.555***
				(0.153)				(0.149)
b_5 : Constant	-2.813***	-2.672***	-2.395***	-2.538***	-2.362***	-2.219***	-1.938***	-2.108***
	(0.048)	(0.058)	(0.076)	(0.087)	(0.044)	(0.056)	(0.075)	(0.084)
$b_{5,D}$: D		0.295***	-0.070	0.169		0.208***	-0.164**	0.129
		(0.034)	(0.079)	(0.107)		(0.034)	(0.077)	(0.104)
Observations	351	351	351	351	351	351	351	351
R^2	0.241	0.483	0.527	0.542	0.240	0.414	0.463	0.487

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). Volatilities are measured by the percent standard deviation of industry's real value of shipments.

associated with 0.521% and 0.693% decreases in the relative standard deviations of exports and imports, respectively.

Qualitatively, these association between volatilities and sloping marginal costs are robust on goods classification. According to Column (3), (4), (7), and (8), durable industries have the stronger relationship between the marginal cost coefficients and output volatilities than nondurable industries. $\hat{b}_{1,D}$ is positive at the 1% significance level. The volatilities of exports and imports decrease in economies of scale from sloping marginal costs. These impacts are larger in durables than in nondurables, but it is statistically insignificant.

It is hard to find a clear and robust relationship between nonproduction costs and international business cycles. Impacts of nonproduction costs on industrial business cycles depend on industry goods classification. $\hat{b}_2$ in all Tables 5, 6, and 7 indicates the estimates for economies of scale derived from

Table 6: Regression Results: Volatility of Export and Market Structures

	Log Percent SD of HP-filtered Series				Log Percent SD of Growth Rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS$_{MC}$	-0.440***	-0.521***	-0.459***	-0.404**	-0.454***	-0.519***	-0.453***	-0.400**
	(0.130)	(0.136)	(0.174)	(0.169)	(0.131)	(0.137)	(0.175)	(0.171)
$b_{1,D}$: $D \times$ EOS$_{MC}$			-0.228	-0.427			-0.251	-0.446
			(0.277)	(0.276)			(0.279)	(0.280)
b_2 : EOS$_{NC}$	-0.070	-0.190	-0.377	-0.434*	-0.129	-0.224	-0.457*	-0.495*
	(0.127)	(0.144)	(0.255)	(0.259)	(0.127)	(0.145)	(0.257)	(0.262)
$b_{2,D}$: $D \times$ EOS$_{NC}$			0.280	0.372			0.344	0.403
			(0.285)	(0.311)			(0.287)	(0.314)
b_3 : $\ln \varepsilon$	0.074	0.083	0.083	0.351***	0.066	0.072	0.073	0.320***
	(0.052)	(0.052)	(0.052)	(0.074)	(0.052)	(0.052)	(0.053)	(0.075)
$b_{3,D}$: $D \times \ln \varepsilon$				-0.489***				-0.449***
				(0.102)				(0.103)
b_4 : $\ln \theta_m$		-0.270*	-0.290*	-0.033		-0.214	-0.237	0.030
		(0.158)	(0.159)	(0.221)		(0.159)	(0.160)	(0.224)
$b_{4,D}$: $D \times \ln \theta_m$				-0.334				-0.367
				(0.309)				(0.312)
b_5 : Constant	0.547***	0.383***	0.464***	0.754***	0.616***	0.485***	0.587***	0.869***
	(0.078)	(0.114)	(0.157)	(0.175)	(0.079)	(0.114)	(0.158)	(0.177)
$b_{5,D}$: D		0.080	-0.036	-0.466**		0.065	-0.082	-0.503**
		(0.068)	(0.162)	(0.216)		(0.068)	(0.163)	(0.219)
Observations	351	351	351	351	351	351	351	351
R^2	0.042	0.053	0.057	0.119	0.045	0.052	0.057	0.110

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The relative standard deviation of business cycle components of industry's real exports is relative to the business cycle components of industry's real value of shipments during the equal sample periods.

nonproduction costs. Only some $\hat{b}_2$ in Columns (1) – (2) and (5) – (6) of Tables are statistically significant. However, these results are not robust after controlling for the ratio of value added to output and the nondurable vs durable. Many $\hat{b}_2$ in Columns (3) – (4) and (7) – (8) are insignificant at the 10% level. When they are significant, the nondurable and durable industries have different signs of coefficients in Tables 5 and 7: $\hat{b}_2$ and $\hat{b}_1 + \hat{b}_{2,D}$. According to Columns (4), (7), and (8) in Table 6, $\hat{b}_2$ is negative, but $\hat{b}_1 + \hat{b}_{2,D}$ is zero at the 10% significance level.

Tables 8, 9, and 10 display the relationship between cost structure and cyclicality. As a measurement of cyclicality for each industry, I use correlation to the aggregated business cycle component of outputs that is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year. Tables A5, A6, and A7 reports

Table 7: Regression Results: Volatility of Import and Market Structures

	Log Percent SD of HP-filtered Series				Log Percent SD of Growth Rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	-0.511***	-0.693***	-0.576***	-0.536***	-0.517***	-0.687***	-0.538***	-0.495***
	(0.128)	(0.130)	(0.165)	(0.163)	(0.126)	(0.129)	(0.164)	(0.162)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			-0.261	-0.408			-0.323	-0.476*
			(0.264)	(0.267)			(0.262)	(0.265)
b_2 : EOS_{NC}	-0.111	-0.422***	-0.249	-0.289	-0.147	-0.408***	-0.158	-0.176
	(0.124)	(0.137)	(0.243)	(0.250)	(0.123)	(0.136)	(0.241)	(0.248)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			-0.204	-0.140			-0.302	-0.278
			(0.272)	(0.300)			(0.269)	(0.298)
b_3 : $\ln \varepsilon$	0.129**	0.149***	0.143***	0.338***	0.131***	0.149***	0.140***	0.322***
	(0.051)	(0.050)	(0.050)	(0.072)	(0.050)	(0.049)	(0.049)	(0.071)
$b_{3,D}$: $D \times \ln \varepsilon$				-0.357***				-0.330***
				(0.098)				(0.098)
b_4 : $\ln \theta_m$		-0.700***	-0.710***	-0.520**		-0.588***	-0.599***	-0.380*
		(0.151)	(0.151)	(0.214)		(0.149)	(0.150)	(0.212)
$b_{4,D}$: $D \times \ln \theta_m$				-0.251				-0.316
				(0.299)				(0.296)
b_5 : Constant	0.627***	0.235**	0.131	0.345**	0.646***	0.296***	0.149	0.368**
	(0.077)	(0.108)	(0.150)	(0.169)	(0.076)	(0.107)	(0.149)	(0.168)
$b_{5,D}$: D		0.147**	0.281*	-0.035		0.161**	0.351**	0.021
		(0.064)	(0.155)	(0.209)		(0.064)	(0.153)	(0.208)
Observations	351	351	351	351	351	351	351	351
R^2	0.070	0.132	0.136	0.169	0.075	0.125	0.132	0.163

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The relative standard deviation of business cycle components of industry's real imports is relative to the business cycle components of industry's real value of shipments during the equal sample periods.

the results with the alternative cyclicality measure: the correlation to the business cycle component of real GDP.

According to all Tables 8, 9, and 10, industrial output, exports, and imports are strongly correlated with aggregate GDP when industries have large economies of scale derived from marginal costs. In Columns (1) – (8), the estimated coefficients $\hat{b}_1$ are significantly positive at the 1% level. The benchmark results are reported in Column (2). A 1% increases in economies of scale derived from sloping marginal costs are associated with 0.229, 0.369, and 0.261 increases in correlations of industry output, exports, and imports with aggregate GDP, respectively. To check the robustness of the regression results, I investigate impacts of non-durables and durables on my benchmark regression coefficients. Columns (3) – (4) and (7) – (8) illustrate the robustness of impacts of cost structure on industry-level international business

Table 8: Regression Results: Cyclicality of Output and Market Structures

	Correlation to the Aggregated Business Cycle Component of Outputs							
	HP-filtered Series				Growth Rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	0.217***	0.229***	0.285***	0.287***	0.205***	0.226***	0.304***	0.302***
	(0.055)	(0.057)	(0.069)	(0.069)	(0.049)	(0.052)	(0.063)	(0.063)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			-0.001	-0.002			-0.065	-0.055
			(0.111)	(0.114)			(0.101)	(0.103)
b_2 : EOS_{NC}	-0.417***	-0.333***	0.137	0.186*	-0.392***	-0.333***	0.127	0.152
	(0.053)	(0.060)	(0.102)	(0.107)	(0.048)	(0.055)	(0.093)	(0.097)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			-0.636***	-0.725***			-0.615***	-0.661***
			(0.114)	(0.128)			(0.103)	(0.116)
b_3 : $\ln \varepsilon$	-0.043*	-0.045**	-0.053**	-0.095***	-0.049**	-0.052***	-0.061***	-0.095***
	(0.022)	(0.022)	(0.021)	(0.031)	(0.020)	(0.020)	(0.019)	(0.028)
$b_{3,D}$: $D \times \ln \varepsilon$				0.083**				0.064*
				(0.042)				(0.038)
b_4 : θ_m		0.190***	0.206***	0.250***		0.134**	0.145**	0.153*
		(0.066)	(0.063)	(0.091)		(0.060)	(0.058)	(0.083)
$b_{4,D}$: $D \times \ln \theta_m$				-0.114				-0.036
				(0.127)				(0.115)
b_5 : Constant	0.696***	0.760***	0.522***	0.516***	0.673***	0.733***	0.497***	0.478***
	(0.033)	(0.047)	(0.063)	(0.072)	(0.030)	(0.043)	(0.057)	(0.065)
$b_{5,D}$: D		0.038	0.362***	0.358***		-0.000	0.321***	0.341***
		(0.028)	(0.065)	(0.089)		(0.026)	(0.059)	(0.081)
Observations	351	351	351	351	351	351	351	351
R^2	0.192	0.217	0.281	0.290	0.211	0.222	0.295	0.301

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The aggregated business cycle component of outputs is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year. Table A5 reports the results with the alternative cyclicality measure: the correlation to the business cycle component of GDP.

cycles for durable and nondurable industries. In all cases, $\hat{b}_{1,D}$ is statistically zero at the 10% significance level. Thus, my previous results showing, the impacts of economies of scale from marginal costs on volatility and cyclicality of macroeconomic and trade flows, are robust.

I consider impacts of nonproduction costs on cyclical patterns of output, exports, and imports. According to Columns (1) – (2) and (5) – (6) in Tables 8, 9, and 10, associations between nonproduction costs and cyclicality of output, exports, and imports tend to be statistically negative or zero. However, after controlling for different slopes between nondurable and durable industries, the impacts in nondurable industries, represented by the coefficients $\hat{b}_2$, are statistically positive or zero. However, the impacts of nonproduction inputs on cyclicalities of outputs and imports in durable industries, represented by the

Table 9: Regression Results: Cyclicality of Export and Market Structures

		Correlation to the Aggregated Business Cycle Component of Outputs							
		HP-filtered Series				Growth Rates			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1	: EOS_{MC}	0.372***	0.369***	0.348***	0.349***	0.355***	0.358***	0.323***	0.322***
		(0.065)	(0.068)	(0.086)	(0.087)	(0.057)	(0.060)	(0.076)	(0.077)
$b_{1,D}$	: $D \times \text{EOS}_{MC}$			0.069	0.066			0.102	0.105
				(0.138)	(0.142)			(0.122)	(0.125)
b_2	: EOS_{NC}	-0.191***	-0.108	-0.069	-0.049	-0.088	-0.050	-0.028	-0.008
		(0.063)	(0.071)	(0.127)	(0.133)	(0.055)	(0.063)	(0.112)	(0.117)
$b_{2,D}$	: $D \times \text{EOS}_{NC}$			-0.061	-0.096			-0.041	-0.077
				(0.141)	(0.159)			(0.125)	(0.141)
b_3	: $\ln \varepsilon$	-0.062**	-0.063**	-0.063**	-0.076**	-0.061***	-0.062***	-0.061***	-0.082**
		(0.026)	(0.026)	(0.026)	(0.038)	(0.023)	(0.023)	(0.023)	(0.034)
$b_{3,D}$	: $D \times \ln \varepsilon$				0.027				0.041
					(0.052)				(0.046)
b_4	: $\ln \theta_m$		0.190**	0.195**	0.218*		0.087	0.094	0.107
			(0.078)	(0.079)	(0.114)		(0.069)	(0.070)	(0.100)
$b_{4,D}$	: $D \times \ln \theta_m$				-0.053				-0.038
					(0.158)				(0.140)
b_5	: Constant	0.384***	0.429***	0.414***	0.416***	0.321***	0.347***	0.342***	0.335***
		(0.039)	(0.056)	(0.078)	(0.090)	(0.034)	(0.050)	(0.069)	(0.079)
$b_{5,D}$	: D		0.069**	0.092	0.084		0.023	0.032	0.038
			(0.033)	(0.081)	(0.111)		(0.030)	(0.071)	(0.098)
Observations		351	351	351	351	351	351	351	351
R^2		0.127	0.154	0.155	0.156	0.133	0.139	0.141	0.143

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The aggregated business cycle component of outputs is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year. Table A6 reports the results with the alternative cyclicality measure: the correlation to the business cycle component of GDP.

sum of coefficients $\hat{b}_2 + \hat{b}_{2,D}$, are negative at the 5% significance level. The values of $\hat{b}_2 + \hat{b}_{2,D}$ for exports are statistically zero at the 10% significance level. Because of such inconsistent and insignificant estimation results about both volatilities and cyclicalities, I leave these issues related to nonproduction costs for future research.

Table 10: Regression Results: Cyclicality of Import and Market Structures

	Correlation to the Aggregated Business Cycle Component of Outputs							
	HP-filtered Series				Growth Rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	0.232***	0.261***	0.268***	0.299***	0.194***	0.224***	0.225***	0.235***
	(0.061)	(0.062)	(0.079)	(0.078)	(0.056)	(0.058)	(0.073)	(0.073)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			0.032	-0.064			0.062	0.037
			(0.127)	(0.127)			(0.117)	(0.119)
b_2 : EOS_{NC}	-0.303***	-0.151**	0.007	0.164	-0.202***	-0.111*	0.091	0.186*
	(0.060)	(0.066)	(0.116)	(0.119)	(0.054)	(0.061)	(0.108)	(0.112)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			-0.218*	-0.505***			-0.281**	-0.453***
			(0.130)	(0.143)			(0.121)	(0.134)
b_3 : $\ln \varepsilon$	0.001	-0.003	-0.005	-0.037	-0.027	-0.031	-0.034	-0.089***
	(0.025)	(0.024)	(0.024)	(0.034)	(0.022)	(0.022)	(0.022)	(0.032)
$b_{3,D}$: $D \times \ln \varepsilon$				0.079*				0.113***
				(0.047)				(0.044)
b_4 : $\ln \theta_m$		0.343***	0.351***	0.637***		0.204***	0.215***	0.337***
		(0.072)	(0.072)	(0.102)		(0.067)	(0.067)	(0.096)
$b_{4,D}$: $D \times \ln \theta_m$				-0.581***				-0.275**
				(0.142)				(0.133)
b_5 : Constant	0.645***	0.768***	0.690***	0.802***	0.580***	0.667***	0.569***	0.590***
	(0.037)	(0.052)	(0.072)	(0.080)	(0.034)	(0.048)	(0.067)	(0.076)
$b_{5,D}$: D		0.053*	0.160**	-0.058		0.006	0.142**	0.082
		(0.031)	(0.074)	(0.099)		(0.029)	(0.069)	(0.093)
Observations	351	351	351	351	351	351	351	351
R^2	0.096	0.162	0.169	0.211	0.074	0.098	0.113	0.138

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The aggregated business cycle component of outputs is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year. Table A7 reports the results with the alternative cyclicality measure: the correlation to the business cycle component of GDP.

4 Theoretical Framework: Sloping Marginal Cost Curve and Within-firm Market Interdependence

This section presents an individual firm's problem with a sloping marginal cost curve. Monopolistic competition implies that an individual firm's decision does not affect aggregate variables such as total demands, wages, price indices, and exchange rate. The individual firm's maximization problem is time separable. Each industry can be indexed by its marginal cost coefficient. Thus, I drop the industry (s) and time index (t) in Section 4. The section focuses on individual firm's decisions without general equilibrium effects. Thus, all aggregate variables are exogenously given. Section 5 will construct a dynamic general equilibrium model. There are two countries, home and foreign. I denote foreign variables by an asterisk.

4.1 Heterogeneous Firms with Sloping Marginal Cost Curve

There is a continuum of firms in each country and each industry. The mass of firms is given in this section. Home firms are heterogeneous in firm-specific productivity denoted by $z \in [z_{min}, \infty)$ where $z_{min} \geq 1$. There is the industry's productivity denoted by $Z > 0$. Thus, a firm's productivity is Zz. Each firm produces a different variety $\omega \in \Omega$. An individual firm decides the quantity of supply to the domestic and export market denoted by $y_D \geq 0$ and $y_X \geq 0$, respectively. An exporter should ship τy_X units of the good for y_X units to reach the export market where $\tau > 1$ represents the iceberg export costs.

The real total cost function in terms of the home consumption basket is

$$\mathrm{tc}\left(y; w, Z, z\right) = \left[\frac{w}{(Zz)^{\frac{1}{\alpha}}}\right] y^{\frac{1}{\alpha}} + f_X \frac{w}{\alpha Z^{\frac{1}{\alpha}}} \mathrm{I}\left\{y_X \in \mathbb{R}_+\right\}, \tag{28}$$

where $y = y_D + \tau y_X \geq 0$ is the total quantity produced, w is the real wage, and $f_X > 0$ is the fixed export costs in unit of efficiency labor. $\mathrm{I}\{\cdot\}$ is the indicator function.[24] Allowing a sloping marginal cost curve is a key feature of my model, which is represented by the marginal cost coefficient, denoted by α, in Equation (28). Conventional new trade and open macroeconomic models introduced by Krugman (1979, 1980), Melitz (2003), and Ghironi and Melitz (2005) fix $\alpha = 1$.[25]

The marginal cost coefficient indexes the firm's marginal cost structure. The marginal cost function is decreasing, constant, or increasing in y when $\alpha > 1$, $\alpha = 1$, or $\alpha < 1$, respectively. If the marginal cost curve is sloping ($\alpha \neq 1$), each firm's decisions in one market have effects on the profitability and decisions in other markets. When each firm's marginal cost does not vary with production level ($\alpha = 1$),

[24] The indicator function of $A \subset X$ is a function $\mathrm{I}\{x \in A\} : X \to \{0, 1\}$ defined by

$$\mathrm{I}\{x \in A\} = \begin{cases} 1 & \text{if } \; x \in A \\ 0 & \text{if } \; x \notin A \end{cases} .$$

[25] More precisely, the cost function with $\alpha = 1$ is the same as it of Ghironi and Melitz (2005). In Krugman (1979, 1980), there are no fixed operating costs in all markets. Thus, all firms sale in all markets. Economies of scale are from the sunk entry costs. In Melitz (2003) and Ghironi and Melitz (2005), there are fixed operating costs in an export markets. Thus, least productive firms do not exports. The difference between two papers is that firms in Ghironi and Melitz (2005) do not pay fixed operating costs in a domestic market. Thus, sunk entry costs solely generate economies of scale in Ghironi and Melitz (2005). Most open macroeconomic models including this paper use the cost function of Ghironi and Melitz (2005) rather than it of Melitz (2003) because adding fixed operating costs in a domestic market does not play a crucial role in international business cycles.

the decisions in each market can be separated because the marginal cost is unchanged. $\alpha > 1$ causes positive within-firm market interdependence: large export sales lower the marginal cost, which leads to large domestic sales due to high productivity, and vice versa. Inversely, $\alpha < 1$ yields negative within-firm market interdependence: large export sales raise the marginal cost, which diminishes domestic sales due to low productivity, and vice versa.

A firm indexed by its firm-specific productivity z chooses its prices and quantities of supply to maximize its profit:

$$\max \rho_D y_D + Q \rho_X y_X - \mathrm{tc}\left(y; w, Z, z\right)$$
$$\text{subject to } y = y_D + \tau y_X,$$

where ρ_D and ρ_X are real prices relative to the price index in the destination market. Q is the real exchange rate. In each monopolistically competitive market for each industry, the firm faces the following individual demands in home and foreign markets, respectively.

$$y_D = \left(\rho_D\right)^{-\theta} D, \text{ and } y_X = \left(\rho_X\right)^{-\theta} D^*,$$

where D and D^* are the effective home and foreign real demand for the industry in terms of destination consumption basket. To focus on within-firm level channel, this section model assumes a partial equilibrium. Thus, there are no changes in relative prices (sectoral and international). Thus, D and D^* are fixed. I will extend the model to a general equilibrium in the next section. The elasticity θ is constant and larger than one, so its markups in both markets are identical and constant: $\mu = \theta / \left(\theta - 1\right)$. To generate the existence of a unique equilibrium in a firm's maximization problem, I assume that the marginal cost coefficient is smaller than the markup: $\mu > \alpha$.

4.2 Exporter's and Non-exporter's Profit Maximization

I begin by solving a firm's profit maximization for given its export decision ($m_X = \mathrm{I}\left\{y_X \in \mathbb{R}_+\right\}$). For convenience, define the effective world demand by $ED\left(m_X\right) = D + m_X \left(\tau / Q\right)^{1-\theta} QD^*$. Then, a non-exporter's effective world demand is $ED_N = ED\left(m_X = 0\right)$ that is equal to the domestic demand. An exporter's effective world demand is $ED_X = ED\left(m_X = 1\right)$. ED_X increases in the real exchange rate but decreases in the iceberg trade costs. An exporter sell in both markets, thus its effective world demand is always larger than it of a non-exporter: $ED_X > ED_N$. If they have the same productivity, exporters enjoy more demand and higher revenue than non-exporters. There is a revenue side export motivation for all firms.

Taking as given the firm's export decision, its real marginal cost is given by

$$\mathrm{mc}\,(z; m_X) = \left[\frac{w}{\alpha\,(Zz)^{\frac{1}{\alpha}}}\right][y(z; m_X)]^{\frac{1}{\alpha}-1} = \frac{1}{\mu}\left\{\mu\left[\frac{w}{\alpha\,(Zz)^{\frac{1}{\alpha}}}\right][ED\,(m_X)]^{\frac{1}{\alpha}-1}\right\}^{\frac{\alpha\zeta}{\theta-1}}, \tag{29}$$

where $y\,(z; m_X)$ is the quantity produced for given export decision, and $\zeta = 1/\,(\mu - \alpha)$ is positive by assumption ($\mu > \alpha$). Thus, a non-exporter's real marginal cost is $\mathrm{mc}_N\,(z) = \mathrm{mc}\,(z; m_X = 0)$, and an exporter's real marginal cost is $\mathrm{mc}_X\,(z) = \mathrm{mc}\,(z; m_X = 1)$. The optimal prices are equal to firm's markups multiplied by its marginal cost. Thus, the prices for a given export decision are given by

$$\rho_D\,(z; m_X) = \left\{\mu\left[\frac{w}{\alpha\,(Zz)^{\frac{1}{\alpha}}}\right][ED\,(m_X)]^{\frac{1}{\alpha}-1}\right\}^{\frac{\alpha\zeta}{\theta-1}}, \tag{30}$$

$$\rho_X\,(z; m_X) = \left(\frac{\tau}{Q}\right)\rho_D\,(z; m_X) \qquad \text{if} \quad m_X = 1. \tag{31}$$

If $\alpha = 1$, a firm's price in a domestic market does not change wether it exports or not because there is no impact of effective world demand on prices under constant marginal cost. With $\alpha > 1$, a firm can set lower prices if it exports, due to export efficiency gains derived from the decreasing marginal costs. The opposite holds for $\alpha < 1$.

In the equilibrium, the domestic and export sales in terms of home consumption are

$$\rho_D\,(z; m_X)\,y_D\,(z; m_X) = [\rho_D\,(z; m_X)]^{1-\theta}\,D \tag{32}$$

$$\rho_X\,(z; m_X)\,y_X\,(z; m_X) = [\rho_X\,(z; m_X)]^{1-\theta}\,QD^* \qquad \text{if} \quad m_X = 1. \tag{33}$$

Thus, each individual exporter's domestic and export sales are complements if $\alpha > 1$ but are substitutes if $\alpha < 1$. When a firm exports,

$$\frac{\partial \rho_D y_D}{\partial QD^*} \gtreqless 0 \quad \text{if and only if} \quad \alpha \gtreqless 1,$$

$$\frac{\partial \rho_X y_X}{\partial D} \gtreqless 0 \quad \text{if and only if} \quad \alpha \gtreqless 1.$$

In other words, the constant marginal cost causes no within-firm interdependence. The decreasing and increasing marginal costs imply positive and negative within-firm interdependence, respectively.

4.3 Profit Curve and Export Decision

The firm's maximized profit for a given export decision is

$$\begin{aligned}\pi(z;m_X) &= \frac{1}{\zeta}\left[\rho_D(z;m_X)\,y_D(z;m_X) + Q\rho_X(z;m_X)\,y_X(z;m_X)\right] - m_X f_X \frac{w}{\alpha Z^{\frac{1}{\alpha}}} \\ &= \frac{1}{\zeta\mu}\left[\mu\frac{w}{\alpha(Zz)^{\frac{1}{\alpha}}}\right]^{-\alpha\zeta}\left[ED(m_X)\right]^{1+(\alpha-1)\zeta} - m_X f_X \frac{w}{\alpha Z^{\frac{1}{\alpha}}}, \end{aligned} \tag{34}$$

where it is an increasing function of the effective world demand ($ED(m_X)$) because $\zeta = (\mu-\alpha)^{-1}$ and $\theta > 1$ guarantee $1 + (\alpha-1)\zeta = (\mu-1)(\mu-\alpha) > 0$. Further, the profit is convex, linear, or concave in effective world demand if and only if $\alpha > 1, = 1$, or < 1. The profit is decomposed into the domestic market profit ($\pi_D(z;m_X)$) and export market profit ($\pi_X(z;m_X)$) as follows.[26]

$$\pi_D(z;m_X) = \frac{1}{\zeta\mu}\left[\mu\frac{w}{\alpha(Zz)^{\frac{1}{\alpha}}}\right]^{-\alpha\zeta}\left[ED(m_X)\right]^{(\alpha-1)\zeta} D \tag{35}$$

$$\pi_X(z;m_X) = m_X\left\{\left[\frac{\pi_D(z;m_X)}{D}\right]\left(\frac{\tau}{Q}\right)^{1-\theta} QD^* - f_X\frac{w}{\alpha Z^{\frac{1}{\alpha}}}\right\} \tag{36}$$

The previous assumption ($\mu > \alpha \Leftrightarrow \zeta > 0$) guarantees that all firms participate in the domestic market. If a marginal cost function is flat ($\alpha = 1$), the domestic profit is independent of the export decision. The profit function is linearly separable in the domestic and export market demands, so there is no firm-level market interdependence. In contrast, the decreasing marginal cost curve ($\alpha > 1$) causes positive interdependence between firm's decisions in the domestic and export markets. Similarly, the increasing marginal cost curve ($\alpha < 1$) implies negative interdependence between two markets at the firm level.

[26]Since the quantities supplied in the domestic and export markets are not linearly separable in the total cost function, it is hard to distinguish between the domestic and export profits. However, it is easy to separate the domestic and export revenues (sales). I assume that the ratio of variable costs in the domestic market to them in the export market equals to the ratio of the domestic market revenue to the export market revenue. Further, that way of decomposition implies that firm's marginal costs in production do not vary a destination of markets. Excluding the iceberg and fixed export costs, there is no reason that the firm's production and cost functions change because it sell the same good in the domestic and export markets.

For $m_X = 1$,

$$\frac{\partial \pi_D}{\partial QD^*} \gtreqless 0 \quad \text{if and only if} \quad \alpha \gtreqless 1,$$
$$\frac{\partial \pi_X}{\partial D} \gtreqless 0 \quad \text{if and only if} \quad \alpha \gtreqless 1,$$

because marginal costs depend on the total quantity produced when the cost curve is not linear.

A firm's profit with firm-specific productivity z is $\pi(z) = \max\{\pi(z; m_X = 0), \pi(z; m_X = 1)\}$. Since its profit strictly increases along with its firm-specific productivity, more productive firms export. An export decision can be represented by the export productivity cutoff, denoted by z_X. The cutoff level satisfies the indifferent condition as follows.

$$\pi(z_X; m_X = 0) = \pi(z_X; m_X = 1)$$

A firm exports when its firm-specific productivity is higher than the cutoff: $z > z_X$.

If there is no firm-level market interdependence derived from a marginal cost curve, then the condition can be expressed by $\pi_X(z_X, m_X = 1) = 0$, because the total profit function is linearly separable in the domestic market profit and export market profit. Thus, the flat marginal cost curve implies that a firm only export when its profit is positive in an export market. However, with a decreasing marginal cost curve, some firms export despite negative profits in the export market. By exporting, firms increase their output and lower their marginal costs, which increases profits in the domestic market.

$$\pi_X(z_X, m_X = 1) \lesseqgtr 0 \quad \text{if and only if} \quad \alpha \gtreqless 1$$

For the marginally exporting firm ($z = z_X$), export profit is positive, zero, or negative if the marginal cost is increasing, constant, or decreasing, respectively.

The export decision is represented by $m_X(z) = \text{argmax}_{m_X \in \{0,1\}} \pi(z; m_X)$. The export decision and cutoff are

$$m_X(z) = \begin{cases} 1 \quad \text{if} \quad z \geq z_X \quad \text{where } z_X = \left[\frac{\mu \zeta f_X w / \left(\alpha Z^{\frac{1}{\alpha}}\right)}{ED_X^{1+(\alpha-1)\zeta} - ED_N^{1+(\alpha-1)\zeta}}\right]^{\frac{1}{\zeta}} \left[\mu \frac{w}{\alpha (Zz)^{\frac{1}{\alpha}}}\right]^{\alpha} \\ 0 \quad \text{otherwise} \end{cases} . \tag{37}$$

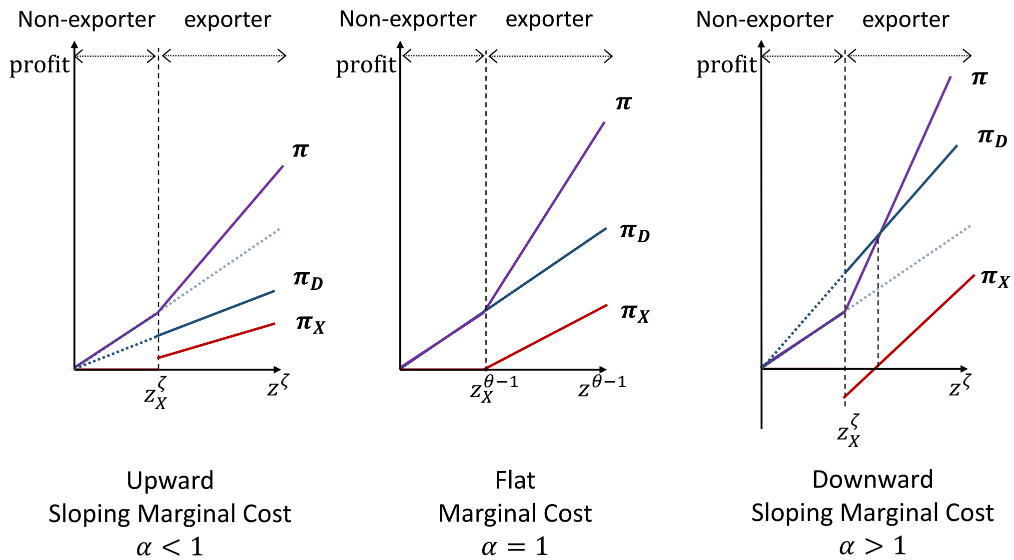

Figure 4: Profit Curves with the Flat and Sloping Marginal Cost Curve

Notes:

The assumptions $\mu > \alpha$ and $\theta > 1$ guarantee that z_X and z_X^* are nonnegative and finite, but they can be less than z_{min}. Thus, the cutoff is $\max\{z_X,\ z_{min}\}$. I assume no corner solution for the cutoff levels: z_X and z_X^* are in (z_{min}, ∞). Then, the cutoff always increases in the iceberg cost, fixed cost, and wage but decreases in the real exchange rate and foreign demand as in Melitz (2003) and Ghironi and Melitz (2005). The interesting part is that the cutoff depends on the cost structure if $\alpha \neq 1$. The decreasing and increasing marginal cost makes negative and positive relationships between the home demand and cutoff level, respectively.

$$\frac{\partial z_X}{\partial D} \lesseqqgtr 0 \quad \text{if and only if} \quad \alpha \gtreqqless 1$$

If the marginal cost function decreases in quantity produced, a high home demand augments home firms' supply in the domestic market and lowers their marginal costs. Thus, the cutoff level falls, and more firms export. However, the cutoff level is higher if the marginal cost is an increasing function due to complementarity of domestic and export profits and sales.

Figure 4 shows the impacts of allowing a sloping marginal cost curve. Under the flat marginal cost curve, exporters and non-exporters have the same slope of domestic market profit curve. Thus, an individual firm's decision to export or not is simply determined by its profit in the export market. The firm exports if the export market profit is positive. However, a sloping marginal cost curve makes the domestic profit curve different for exporters and non-exporters. If $\alpha > 1$, some firms export despite negative profit in the export market because exporting decreases their marginal costs in both markets and increases their domestic profit. Conversely, some firms in the industry with $\alpha < 1$ do not export even though their export market profit is positive due to export efficiency losses. Additionally, in conventional models based on Melitz (2003), the profit is associated with the $(\theta - 1)$-th moments of firm-specific productivity $z^{\theta-1}$, but here this result is be generalized that the profit depends on the ζ-th moment of firm-specific productivity z^{ζ}. For the case with a constant marginal cost curve, $\alpha = 1$, the firm's optimal decision rule equals that in Ghironi and Melitz (2005).

4.4 Market Size, Export Efficiency Gains, and Cost Advantages

Export efficiency gains (or losses) can be measured by $eg\left(z\right) = \mathrm{mc}_N\left(z\right)/\mathrm{mc}_X\left(z\right)$, where $\mathrm{mc}_N\left(z\right)$ and $\mathrm{mc}_X\left(z\right)$ are marginal costs, depending on whether a firm with z does not export or exports, respectively. In Equation (29), the marginal costs can be decomposed into the firm-specific and aggregate parts: $\mathrm{mc}_m\left(z\right) = \overline{\mathrm{mc}}_m z^{\frac{-\zeta}{\theta-1}}$ for $m = N, X$. Thus, that ratio is independent of firm-specific productivity z: $eg\left(z\right) = eg = \overline{\mathrm{mc}}_N/\overline{\mathrm{mc}}_X$. By using Equation (29), the measure is given by $eg = \left(ED_N/ED_X\right)^{(1-\alpha)\zeta/(\theta-1)}$.

Exporting decreases individual firm's marginal costs if and only if $eg > 1$. Thus, the efficiency gains or losses are $eg > 1$ or $eg < 1$, respectively. The slop of marginal cost curve is associated with export gains and losses.

$$eg \gtreqless 1 \quad \text{if and only if} \quad \alpha \gtreqless 1,$$

because $ED_N < ED_X$. With economies of scale derived from the decreasing marginal cost, exporting lowers the firm's marginal cost. Thus, exporters enjoy efficiency gains. In other words, the decreasing marginal cost curve generates a cost-side export motivation, a firm exports to reduce its costs.

To investigate the impact of market size, I consider home export efficiency gains (or losses) relative to the foreign country.

$$\frac{eg}{eg^*} = \left\{ \frac{1 + \left(\tau Q\right)^{1-\theta}\left[D/\left(QD^*\right)\right]}{1 + \left(\tau/Q\right)^{1-\theta}\left[\left(QD^*\right)/D\right]} \right\}^{\frac{(1-\alpha)\zeta}{\theta-1}}, \tag{38}$$

where the term in braces increases in the home market size relative to the foreign market size: $D/(QD^*)$. Therefore,

$$\frac{\partial eg/eg^*}{\partial D/(QD^*)} \lesseqgtr 0 \quad \text{if and only if} \quad \alpha \gtreqless 1.$$

If a marginal cost curve decreases in output, home export efficiency gains relative to the foreign ones decreases in the home market size relative to the foreign country. During a home boom, a large market size makes exporting less attractive for a home firm if its marginal cost curve decreases in its production level. This mechanism causes inter-industry resource shifts to industries with small economies of scale from industries with large economies of scale in a more productive country. The opposite holds for an increasing marginal cost curve.

In contrast to the above export efficiency gains channel, a large market size makes the more productive economy concentrated in industries with large economies of scale because declines in home production costs – by definition of economies of scale – imply cost advantages.

$$\frac{\partial \mathrm{mc}_N/\mathrm{mc}_N^*}{\partial D/(QD^*)} \lesseqgtr 0 \quad \text{if and only if} \quad \alpha \gtreqless 1$$
$$\frac{\partial \mathrm{mc}_X/\mathrm{mc}_X^*}{\partial D/(QD^*)} \lesseqgtr 0 \quad \text{if and only if} \quad \alpha \gtreqless 1$$

If $\alpha > 1$, home marginal costs relative to the foreign marginal costs for both exporters and non-exporters decreases in the home market size relative to the foreign ones. The opposite holds for $\alpha < 1$.

5 Dynamic Stochastic General Equilibrium Model

Based on Section 4, this section outlines the construction of a two-country two-industry dynamic stochastic general equilibrium model to investigate the effects of economies of scale derived from marginal costs on industry-level international trade and business cycles. The key feature is that the model allows for two industries, indexed by $s = A$ and $s = B$, with different slopes of marginal cost curves that generate economies of scale and within-firm market interdependence.

There are two symmetric countries, home and foreign. All parameters are identical across countries. As in Section 4, I denote foreign variables with an asterisk. In each country, there is a continuum of identical households in a unit interval $[0, 1]$. In each country and industry, there is a continuum of firms that is endogenously determined.

5.1 Preference and Demand: Representative Household and Capital Producer

In each country, there is a continuum of identical households in a unit interval $[0,\ 1]$. The preference of the representative home household is represented by the time separable utility as follows. At time t_0,

$$\mathbb{E}_{t_0}\left[\sum_{t=t_0}^{\infty}\beta^{t-t_0}U\left(C_t,L_t\right)\right],$$

where $C_t \geq 0$ and $L_t \in [0,1]$ are the home overall consumption basket and the total labor supply, respectively. $\beta \in (0,1)$ is the subjective discount factor.

In an industry s, an individual firm produces a differentiated good indexed by $\omega \in \Omega^s$. The industry s consumption basket is defined over a continuum of goods Ω^s. In each period t, only $\Omega_t^s \subseteq \Omega^s$ is available. I assume the constant elasticity of substitution across industries and across products in each industry for the consumption basket. Then, the aggregate and industry consumption basket is specified as

$$C_t = \left[\left(\phi^A\right)^{\frac{1}{\psi}}\left(C_t^A\right)^{\frac{\psi-1}{\psi}} + \left(\phi^B\right)^{\frac{1}{\psi}}\left(C_t^B\right)^{\frac{\psi-1}{\psi}}\right]^{\frac{\psi}{\psi-1}} \quad \text{and} \quad C_t^s = \left\{\int_{\omega\in\Omega^s}\left[c_t^s\left(\omega\right)\right]^{\frac{\theta-1}{\theta}}d\omega\right\}^{\frac{\theta}{\theta-1}}.$$

The share parameter of each industry denoted by $\phi^s \in (0,1)$ satisfies $\phi^A + \phi^B = 1$. ψ and θ are the constant elasticity of substitution across industries and goods, respectively. To focus on impacts of economies of scale, I assume that elasticities are identical across industries.

The price of individual good $\omega \in \Omega_t^s$ is denoted by $p_t^s\left(\omega\right) \geq 0$. The corresponding overall and industry welfare-based price indices (WPIs) are denoted by P_t and P_t^s, respectively:

$$P_t = \left[\phi^A\left(P_t^A\right)^{1-\psi} + \phi^B\left(P_t^B\right)^{1-\psi}\right]^{\frac{1}{1-\psi}} \quad \text{and} \quad P_t^s = \left\{\int_{\omega\in\Omega_t^s}\left[p_t^s\left(\omega\right)\right]^{1-\theta}d\omega\right\}^{\frac{1}{1-\theta}}.$$

The welfare-based real exchange rate is defined by $Q_t = \varepsilon_t P_t^*/P_t$ where ε_t is the nominal exchange rate. The real price of good ω is defined by $\rho_t^s\left(\omega\right) = p_t^s\left(\omega\right)/P_t$. Similarly, the real industry price is defined by $\rho_t^s = P_t^s/P_t$. Hence, the home demand function of each good ω in industry s is given by

$$c_t^s\left(\omega\right) = \left[\frac{p_t^s\left(\omega\right)}{P_t}\right]^{-\theta}\left(\frac{P_t^s}{P_t}\right)^{\theta-\psi}\phi^s C_t = \left[\rho_t^s\left(\omega\right)\right]^{-\theta}\left(\rho_t^s\right)^{\theta-\psi}\phi^s C_t. \tag{39}$$

Table 11: Firm's Optimal Decisions in Each Industry

Export Decision	
$m_t^s(z) = 0$	if $z < z_{X,t}^s$
$m_t^s(z) = 1$	if $z \geq z_{X,t}^s$
Effective world demand	
$ED_t^s(z) = ED_{N,t}^s = (\rho_t^s)^{\theta-\psi}\,\phi^s C_t$	if $z < z_{X,t}^s$
$ED_t^s(z) = ED_{X,t}^s = (\rho_t^s)^{\theta-\psi}\,\phi^s C_t + (\rho_t^{s*})^{\theta-\psi}\left(\frac{\tau_t^s}{Q_t^s}\right)^{1-\theta} Q_t^s \phi^s C_t^*$	if $z \geq z_{X,t}^s$
Prices	
$\rho_{D,t}^s(z) = \left[\mu \frac{w_t}{\alpha^s (Z_t^s)^{\frac{1}{\alpha^s}}}\right]^{\frac{\alpha^s \zeta^s}{\theta-1}} \left[ED_t^s(z)\right]^{\frac{-(\alpha^s-1)\zeta^s}{\theta-1}} z^{\frac{-\zeta^s}{\theta-1}}$	for all z
$\rho_{X,t}^s(z) = \left(\frac{\tau_t^s}{Q_t^s}\right)\rho_{D,t}^s(z)$	if $z \geq z_{X,t}^s$
Sales	
$\rho_{D,t}^s(z)\,y_D(z) = \left[\rho_{D,t}^s(z)\right]^{1-\theta}(\rho_t^s)^{\theta-\psi}\,\phi^s C_t$	for all z
$Q_t \rho_{X,t}^s(z)\,y_X(z) = 0$	if $z < z_{X,t}^s$
$Q_t \rho_{X,t}^s(z)\,y_X(z) = \left[\rho_{X,t}^s(z)\right]^{1-\theta} Q_t (\rho_t^{s*})^{\theta-\psi}\,\phi^s C_t^*$	if $z \geq z_{X,t}^s$
Profit in Each Market	
$\pi_{D,t}^s(z) = \left(\frac{1}{\zeta^s \mu}\right)\rho_{D,t}^s(z)\,y_D(z)$	for all z
$\pi_{X,t}^s(z) = 0$	if $z < z_{X,t}^s$
$\pi_{X,t}^s(z) = \left(\frac{1}{\zeta^s \mu}\right) Q_t \rho_{X,t}^s(z)\,y_X(z) - f_{X,t}^s \frac{w_t}{(Z_t^s)^{\frac{1}{\alpha}}}$	if $z \geq z_{X,t}^s$
Export Cutoff	
$z_{X,t}^s = \left\{\frac{\mu \zeta^s f_{X,t}^s w_t / \left[\alpha^s (Z_t^s)^{\frac{1}{\alpha^s}}\right]}{\left(ED_{X,t}^s\right)^{1+(\alpha^s-1)\zeta^s} - \left(ED_{N,t}^s\right)^{1+(\alpha^s-1)\zeta^s}}\right\}^{\frac{1}{\zeta^s}} \left[\mu \frac{w_t}{\alpha^s (Z_t^s)^{\frac{1}{\alpha^s}}}\right]^{\alpha^s}$	

5.2 Heterogeneous Firms and Their Averages

A firm is born with its specific productivity z that does not change over time. The firm's total cost function is

$$\mathrm{tc}^s\left(y_t^s; w_t, Z_t^s, z\right) = \left[\frac{w_t}{(Z_t^s z)^{\frac{1}{\alpha^s}}}\right](y_t^s)^{\frac{1}{\alpha^s}} + f_{X,t}^s \frac{w_t}{\alpha^s (Z_t^s)^{\frac{1}{\alpha^s}}} \mathrm{I}\left\{y_{X,t}^s \in \mathbb{R}_+\right\},$$

where Z_t^s is the aggregate productivity of s industry. $f_{X,t}^s$ is the fixed export cost in efficient labor units.

In each period, a firm with firm-specific productivity z chooses its prices and quantities of supply to maximize its profit: for each $s = A$ and B,

$$\max_{\left\{\rho_{m,t}^s \geq 0,\, y_{m,t}^s \geq 0\right\}_{m=D,\, X}} \rho_{D,t}^s y_{D,t}^s + Q_t \rho_{X,t}^s y_{X,t}^s - \mathrm{tc}^s \left(y_t^s; w_t, Z_t^s, z\right)$$

$$\text{subject to} \quad y_t^s = y_{D,t}^s + \tau_t y_{X,t}^s,$$

$$y_{D,t}^s = \left(\rho_{D,t}^s\right)^{-\theta} \left(\rho_t^s\right)^{\theta-\psi} \phi^s C_t, \text{ and } y_{X,t}^s = \left(\rho_{X,t}^s\right)^{-\theta} \left(\rho_t^{s*}\right)^{\theta-\psi} \phi^s C_t^*,$$

where $\rho_{D,t}^s = p_{D,t}^s / P_t$ and $\rho_{X,t}^s = p_{X,t}^s / P_t^*$ are real prices relative to the aggregate price index in the destination market. Table 11 summarizes the firm's solution to the maximization problem for given its firm-specific productivity z.

In each period t, a mass N_t^s of firms produce in the home country for each industry s. To focus on heterogeneous marginal cost structures, I assume that industries A and B have identical distribution functions for firm-specific productivity, denoted by $G(\cdot)$ with support on $[z_{min}, \infty)$. As in the partial equilibrium model, the fixed export costs cause least productive firms not to export. Only firms with high productivity $z > z_{X,t}^s$ become an exporter. Among firms there are $N_{X,t}^s = \left[1 - G\left(z_{X,t}^s\right)\right] N_t^s$ exporters. The rest of the firms $N_{N,t}^s = G\left(z_{X,t}^s\right) N_t^s$ sell only domestically. To summarize all the information on the productivity distributions relevant for all aggregate variables as in Melitz (2003), define average productivity levels for different groups as follows. For each $s = A$ and B,

$$\text{All firms:} \qquad \tilde{z}_D^s = \left[\int_{z_{min}}^{z_{max}} z^{\zeta^s} dG(z)\right]^{\frac{1}{\zeta^s}},$$

$$\text{Non-exporters:} \qquad \tilde{z}_{N,t}^s = \left[\int_{z_{min}}^{z_{X,t}^s} z^{\zeta^s} \frac{dG(z)}{G\left(z_{X,t}^s\right)}\right]^{\frac{1}{\zeta^s}},$$

$$\text{Exporters:} \qquad \tilde{z}_{X,t}^s = \left[\int_{z_{X,t}^s}^{z_{max}} z^{\zeta^s} \frac{dG(z)}{1 - G\left(z_{X,t}^s\right)}\right]^{\frac{1}{\zeta^s}}.$$

Then, these satisfy

$$\left(\tilde{z}_D^s\right)^{\zeta^s} = \left(\frac{N_{N,t}^s}{N_t^s}\right) \left(\tilde{z}_{N,t}^s\right)^{\zeta^s} + \left(\frac{N_{X,t}^s}{N_t^s}\right) \left(\tilde{z}_{X,t}^s\right)^{\zeta^s} \quad \text{for} \quad s = A,\ B. \tag{40}$$

I assume that the distribution of z has finite ζ^s-th moments for every industry: $\left(\tilde{z}_D^s\right)^{\zeta^s} = \left(\tilde{z}_D^{s*}\right)^{\zeta^s} < \infty$.

In line with Melitz (2003), the productivity averages are constructed in such way that $\pi_{D,t}^s\left(\tilde{z}_{N,t}^s\right)$

and $\pi^s_{D,t}\left(\tilde{z}^s_{X,t}\right)$ are the average domestic market profit of non-exporters and exporters, respectively. The average export market profit of exporters is $\pi^s_{X,t}\left(\tilde{z}^s_{X,t}\right)$. The export market profit of non-exporters is zero: $\pi^s_{X,t}\left(\tilde{z}^s_{N,t}\right) = 0$ because $\tilde{z}^s_{N,t} < z^s_{X,t}$. The average profit of all home firms is given by

$$\tilde{\pi}^s_t = G\left(z^s_{X,t}\right)\pi^s_t\left(\tilde{z}^s_{N,t}\right) + \left[1 - G\left(z^s_{X,t}\right)\right]\pi^s_t\left(\tilde{z}^s_{X,t}\right). \tag{41}$$

For each industry, the average relative price of firms in their domestic market is

$$\tilde{\rho}^s_{D,t} = \left\{G\left(z^s_{X,t}\right)\left[\rho^s_{D,t}\left(\tilde{z}^s_{N,t}\right)\right]^{1-\theta} + \left[1 - G\left(z^s_{X,t}\right)\right]\left[\rho^s_{D,t}\left(\tilde{z}^s_{X,t}\right)\right]^{1-\theta}\right\}^{1/(1-\theta)}, \tag{42}$$

which does not equal $\rho^s_{D,t}\left(\tilde{z}^s_D\right)$ if $\alpha^s \neq 1$. The average relative price of firms in their export market is

$$\tilde{\rho}^s_{X,t} = \rho^s_{X,t}\left(\tilde{z}^s_{X,t}\right), \tag{43}$$

in the destination consumption basket. By the definition of welfare based industry price index, the relative prices satisfy that

$$\left(\rho^s_t\right)^{1-\theta} = N^s_t\left(\tilde{\rho}^s_{D,t}\right)^{1-\theta} + N^{s*}_{X,t}\left(\tilde{\rho}^{s*}_{X,t}\right)^{1-\theta} \quad \text{for} \quad s = A,\ B. \tag{44}$$

5.3 Firm Entry and Exit

As in Ghironi and Melitz (2005), I assume a one period time-to-build lag for entrants. Entrants at t start to produce at $t+1$. Additionally, every firm faces exogenous death shocks with a constant probability $\delta \in (0,1)$ at the end of each period. Thus, the law of motion for the number of firms in the home industry s is given by $N^s_t = (1-\delta)\left(N^s_{t-1} + N^s_{E,t-1}\right)$ where $N^s_{E,t-1}$ is the mass of entrants at $t-1$.

Forward looking behavior and rational expectations imply that domestic firm entry is decided based on the present value of the expected future stream of profits. The value of entry $\tilde{\nu}^s_t$ is

$$\tilde{\nu}^s_t = \mathbb{E}_t\left[\sum_{i=t+1}^{\infty}\left[\beta(1-\delta)\right]^{i-t}\left(\frac{\partial U_i}{\partial C_i}/\frac{\partial U_t}{\partial C_t}\right)\tilde{\pi}^s_i\right] \quad \text{for} \quad s = A,\ B. \tag{45}$$

Then, the free entry condition is represented by

$$\tilde{\nu}^s_t = f^s_{E,t}\frac{w_t}{\left(Z^s_t\right)^{\frac{1}{\alpha}}} \quad \text{for} \quad s = A,\ B, \tag{46}$$

Entry occurs until the average value of the firm on the left hand side of Equation (46) equals the entry cost on the right hand side of Equation (46).

The entry costs in units of efficient labor depend on the number of firm entry as follows:

$$f_{E,t}^{s} = f_E + \eta_E \left[\exp \left(N_{E,t}^{s} - N_{E,t-1}^{s} \right) - 1 \right] \quad \text{for} \quad s = A,\ B, \tag{47}$$

where $\eta_E \geq 0$ is the entry adjustment costs parameter. A large entry increases the costs. There are three reasons why I introduce it. First, it is consistent of my empirical framework represented in Equation (7). Second, the parameter decreases the volatility of the number of entrants. The model without entry frictions is too volatile regarding firm entry than the data. Lastly, the entry friction hinder cross-industry resource allocations. In the model, the main path of reallocations is changes in the number of firms (firm entry). Thus, η_E plays the role as resource reallocation costs across industries, which reduce the reallocations in the short run. Under $\eta_E = 0$, the model generates unrealistically drastic resource shifts across industries.

5.4 Household Budget Constraint and Choices

The representative household holds two types of asset: shares in mutual funds of domestic firms and risk-free bonds with real returns. Each country has mutual funds that own all domestic firms and finance entry of new firms. As in Ghironi and Melitz (2005), the household only buys shares of domestic mutual funds. The mutual fund pays a total profit in each period that equals the total profit of all home firms: $N_t^s \tilde{\pi}_t^s$ in terms of the home consumption. The household buys x_{t+1}^s shares in the mutual fund of $N_t^s + N_{E,t}^s$ home firms in s industry. Home entrants in period t will produce and pay dividends in the future period $t+1$.

Each household in two countries can trade risk-free bonds domestically and internationally.[27] Home (foreign) bonds are issued by the home (foreign) household with the home (foreign) consumption real interest rate. In period t, the home household's home and foreign bond holdings are B_t and $B_{*,t}$, respectively. At the end of the period, their home and foreign bond holdings are B_{t+1} and $B_{*,t+1}$, respectively. There are adjustment costs for bond holdings, which prevents the indeterminacy problem. The home household pays quadratic adjustment costs for home and foreign bond holdings of $0.5\eta_B B_{t+1}^2$ and $0.5\eta_B Q_t B_{*,t+1}^2$, respectively.

[27] The assumption is not crucial. The financial autarky, meaning bonds are only traded domestically, shows slower adjustment in impulse responses to asymmetric shocks, but there is no qualitative difference between the two bond trading structures.

The aggregate GDP is defined by $GDP_t = w_t L_t + \sum_{s=A,B} N_t^s \tilde{\pi}_t^s$. Then, the period budget constraint (in units of home consumption) is written as

$$B_{t+1} + Q_t B_{*,t+1} + C_t + \sum_{s=A,B} \tilde{\nu}_t^s \left(N_t^s + N_{E,t}^s\right) x_{t+1}^s$$
$$= (1 + r_t) B_t + Q_t (1 + r_t^*) B_{*,t} + GDP_t + \sum_{s=A,B} \tilde{\nu}_t^s N_t^s x_t^s - \frac{\eta_B}{2} \left(B_{t+1}^2 + Q_t B_{*,t+1}^2\right) + T_t^f, \quad (48)$$

where $\tilde{\nu}_t^s$ is the price (in terms of home consumption basket) of claims to future profits of home firms in industry s. r_{t+1} and r_{t+1}^* are the real interest rates of domestic and foreign bond from t to $t+1$ in terms of domestic and foreign consumption unit, respectively. The adjustment costs transfer to the household: $T_t^f = 0.5\eta_B \left(B_{t+1}^2 + Q_t B_{*,t+1}^2\right)$.

The home household maximizes its expected intertemporal utility subject to Equation (48). The intertemporal decision rules for home and foreign bonds and share holdings are

$$1 + \eta_B B_{t+1} = \beta (1 + r_{t+1}) \mathbb{E}_t \left[\frac{\partial U_{t+1}}{\partial C_{t+1}} / \frac{\partial U_t}{\partial C_t}\right] \quad (49)$$

$$1 + \eta_B B_{*,t+1} = \beta \left(1 + r_{t+1}^*\right) \mathbb{E}_t \left[\left(\frac{\partial U_{t+1}}{\partial C_{t+1}} / \frac{\partial U_t}{\partial C_t}\right) \left(\frac{Q_{t+1}}{Q_t}\right)\right] \quad (50)$$

$$\tilde{\nu}_t^s = \beta (1 - \delta) \mathbb{E}_t \left[\left(\frac{\partial U_{t+1}}{\partial C_{t+1}} / \frac{\partial U_t}{\partial C_t}\right) \left(\tilde{\nu}_{t+1}^s + \tilde{\pi}_{t+1}^s\right)\right] \quad \text{for} \quad s = A,\ B. \quad (51)$$

There is no arbitrage in holding shares of mutual funds, domestic, and foreign bonds. The intratemporal labor supply decision rule is given by

$$-\frac{\partial U_t}{\partial L_t} / \frac{\partial U_t}{\partial C_t} = w_t. \quad (52)$$

The labor market is cleared as follows:

$$L_t = \sum_{s=A,B} \alpha^s \zeta^s \frac{N_t^s \tilde{\pi}_t^s}{w_t} + (1 + \alpha^s \zeta^s) N_{X,t}^s f_{X,t}^s \frac{1}{\alpha \left(Z_t^s\right)^{\frac{1}{\alpha}}} + N_{E,t}^s f_{E,t}^s \frac{1}{\alpha \left(Z_t^s\right)^{\frac{1}{\alpha}}}. \quad (53)$$

The financial market clearing requires $B_{t+1} + B_{t+1}^* = 0$, $B_{*,t+1} + B_{*,t+1}^* = 0$, and $x_{t+1}^s = x_{t+1}^{s*} = 1$ for every period t. In the equilibrium. the aggregate accounting equation can be written as

$$B_{t+1} + Q_t B_{*,t+1} + C_t + I_t = (1 + r_t) B_t + Q_t (1 + r_t^*) B_{*,t} + GDP_t, \quad (54)$$

where $I_t = \sum_{s=A,B} I_t^s$ and $I_t^s = N_{E,t}^s \tilde{\nu}_t^s$ are the aggregate and industry investments, respectively. Internationally traded bonds allow the model to accommodate trade imbalance.

6 Quantitative Analysis

6.1 Calibration

I use following preference (henceforth, GHH preference) introduced by Greenwood et al. (1988), which give a constant Frisch elasticity of labor supply denoted by $\varrho > 0$.

$$U_t\left(C_t, L_t\right) = \frac{\left(C_t - \chi \frac{L_t^{1+1/\varrho}}{1+1/\varrho}\right)^{1-\sigma} - 1}{1-\sigma},$$

where $\sigma > 1$ governs relative risk aversion.

For calibration, I follow Ghironi and Melitz (2005). Each period represents a quarter calendar year. Set values of $\beta = 0.99$ and $\sigma = 2$, which are standard choices for business cycle models. The bond adjustment cost is $\eta_B = 0.0025$, which is sufficient to induce stationarity. Empirical studies report that the aggregate macro Frisch elasticity, ϱ, is between 1 and 2. I choose the middle: $\varrho = 1.5$. χ is chosen to match the steady state labor supply, which is equal to 1/3 for the model. The elasticity of substitution between the two industries is close to one: $\psi = 1.1$. Thus, the expenditure share of each industry does not fluctuate very much over the business cycle.

The group criteria are based on U.S. data. The two industries A and B correspond to industries SEOS and LEOS from Section 3, respectively. Based on my empirical results, I allow different slopes of marginal cost curves but assume identical nonproduction costs: sunk entry and fixed export costs. In Table 1, the aggregate marginal cost curve is slightly downward sloping. Since I want to focus on cost heterogeneity, I choose $\left(\alpha^A,\ \alpha^B\right) = (0.85,\ 1.15)$ for my benchmark model. I set $\phi^A = \phi^B = 0.5$ so that the economy exhibits a flat marginal cost curve at the aggregate level.

To investigate the effects of heterogeneous sloping marginal cost curves, I also consider a comparison with the model in which industries are identical: homogenous flat marginal costs $\alpha^A = \alpha^B = 1$. Thus, economies of scale are only from the sunk entry and fixed export costs. The comparison model (denoted by GM) represents the conventional new trade open macro model introduced by Ghironi and Melitz (2005). The main differences between my conventional model and Ghironi and Melitz (2005)'s model are endogenous labor supply with GHH preference and firm entry frictions.[28]

To focus on cost structure heterogeneity across industries, I assume that remaining parameters are identical across industries. I set $\delta = 0.025$ and $\theta = 3.8$ to match the U.S. plant and macro trade data. The entry and export costs are identical across industries. The steady-state level of fixed entry cost is normalized by 1: $f_E^s = 1$. A wide range of studies use an iceberg trade cost between 20% and 50%. As the benchmark, I set these costs at 30% as in Ghironi and Melitz (2005): $\tau_t = 1.3$. The steady state level of fixed export cost is $f_X^s = 0.3 f_E^s \left[1 - \beta\left(1-\delta\right)\right] / \left[\beta\left(1-\delta\right)\right]$, which implies the fraction is 25% for the given $\tau_t = 1.3$.[29] I choose the entry friction parameter η_E to match the volatility of the numbers of entrants.

In line with Axtell (2001), the firm-specific productivity in each industry follows a Pareto distribution with shape parameter k and support on $[1, \infty)$. Industries A and B have identical distribution functions given by $G\left(z\right) = 1 - z^{-k}$ on the support. For the existence of ζ^s-th moments, k should be larger than ζ^s. In other words, $\alpha^s < \mu - 1/k$. In the previous section, I assumed that $1/\zeta^s = \mu - \alpha^s > 0$ for an inner solution to the firm's problem with positive profits. In sum, the restriction is given by

$$0 < \alpha^s < \min\left\{\mu, \mu - \frac{1}{k}\right\} = \mu - \frac{1}{k}.$$

I set the shape parameter of the Pareto distribution to be $k = 5.5$, which implies that the heavy tail index of firm sales is 1.14.[30] Axtell (2001) documents that the index is close to 1 in the U.S. Census data: the range from 1.06 to 1.10. In Bernard et al. (2003) and Ghironi and Melitz (2005), the index is around 1.25.

6.1.1 Aggregate and Industry-specific Shocks

I consider the aggregate and industry-specific shocks. Let A_t and A_t^s be the home aggregate (common) and industry-specific productivities, respectively. Their steady state values are normalized by one. There are no idiosyncratic shocks in a firm-specific productivity. Then, the industry's total productivity exclud-

[28] The original model in Ghironi and Melitz (2005) assumes inelastic labor supply and no friction ($\eta_E = 0$).

[29] For the comparison model (GM), I set $f_X^s = 0.425 f_E^s \left[1 - \beta\left(1-\delta\right)\right] / \left[\beta\left(1-\delta\right)\right]$ to match 25% of exporters.

[30] I assumed that $k/\zeta^s > 1$ for both Industries A and B. Then, the aggregated level density function of firm-specific productivity can be represented by

$$1 - \text{CDF}\left(z\right) = z^{-\min\left\{\frac{k}{\zeta^A}, \frac{k}{\zeta^B}\right\}} L\left(z\right) \quad \text{for } z \geq 1, \tag{55}$$

where $L\left(\cdot\right)$ is a slowly varying function: $\lim_{x\to\infty} L\left(cx\right)/L\left(x\right) = 1$ for any constant $c > 0$. Thus, the heavy tail index is k/ζ^B because ζ^s is increasing in α^s.

ing a firm-specific productivity is $Z_t^s = A_t A_t^s$. The home and foreign economies are symmetric. The home and foreign aggregate and industry-specific productivities follow multivariate AR(1) process:

$$\begin{bmatrix} \ln A_{t+1} \\ \ln A_{t+1}^{*} \\ \ln A_{t+1}^{A} \\ \ln A_{t+1}^{A*} \\ \ln A_{t+1}^{B} \\ \ln A_{t+1}^{B*} \end{bmatrix} = \begin{bmatrix} \mathbf{\Xi} & \mathbf{0}_{2\times 2} & \mathbf{0}_{2\times 2} \\ \mathbf{0}_{2\times 2} & \mathbf{\Xi} & \mathbf{0}_{2\times 2} \\ \mathbf{0}_{2\times 2} & \mathbf{0}_{2\times 2} & \mathbf{\Xi} \end{bmatrix} \begin{bmatrix} \ln A_{t} \\ \ln A_{t}^{*} \\ \ln A_{t}^{A} \\ \ln A_{t}^{A*} \\ \ln A_{t}^{B} \\ \ln A_{t}^{B*} \end{bmatrix} + \begin{bmatrix} e_{A,t+1} \\ e_{A,t+1}^{*} \\ e_{S,t+1}^{A} \\ e_{S,t+1}^{A*} \\ e_{S,t+1}^{B} \\ e_{S,t+1}^{B*} \end{bmatrix}, \text{ where } \mathbf{\Xi} = \begin{bmatrix} \xi_{AA} & \xi_{AA^*} \\ \xi_{AA^*} & \xi_{AA} \end{bmatrix}. \tag{56}$$

The shock innovations that are denoted by $e_{A,t}$, $e_{A,t}^{*}$, $e_{S,t}^{A}$, $e_{S,t}^{A*}$, $e_{S,t}^{B}$, and $e_{S,t}^{B*}$ are multi-normally distributed with zero mean and variance-covariance matrix $\mathbf{\Sigma}$. The cross-country transmission matrix $\mathbf{\Xi}$ is identical between the aggregate and industry-specific shocks. There is no transmission between aggregate and industry-specific shocks.

To investigate the net impacts of cost structure heterogeneity on propagation mechanisms of aggregate and industry-specific shocks, I assume that industry shock innovations are exchangeable. Also, the aggregate and industry-specific shocks are orthogonal. The variance-covariance matrix takes the form

$$\mathbf{\Sigma} = \begin{bmatrix} \sigma_A^2 \mathbf{\Sigma}_C & \mathbf{0}_{2\times 4} \\ \mathbf{0}_{4\times 2} & \sigma_S^2 \begin{bmatrix} \mathbf{\Sigma}_C & \rho_S \mathbf{\Sigma}_C \\ \rho_S \mathbf{\Sigma}_C & \mathbf{\Sigma}_C \end{bmatrix} \end{bmatrix} \quad \text{where } \mathbf{\Sigma}_C = \begin{bmatrix} 1 & \rho_C \\ \rho_C & 1 \end{bmatrix}. \tag{57}$$

ρ_C and ρ_S are the cross-country and cross-industry correlations of innovations, respectively. σ_A and σ_S are the cross-country and cross-industry standard deviations of innovations, respectively.

According to Foerster et al. (2011), the cross-industry correlation of innovations is low in the U.S.[31] Based on their results, I set $\rho_S = 0.15$. I choose the variance of the shock innovation as 0.005^2 to match GDP volatility in the U.S. data. The shock innovation can be represented by the sum of aggregate and industry-specific innovations: $e_t = e_{A,t} + \sum_{s=A,B} \phi^s e_{S,t}^s$. Then, the variance of shock innovation is $\text{var}(e_t) = \sigma_A^2 + 2\phi^A \phi^B (1+\rho_S)\sigma_S^2$. Let the size of aggregate and industry-specific shocks be $1-\omega_S = \sigma_A^2/\text{var}(e_t)$ and ω_S, respectively. The standard deviations of aggregate and industry-specific shock

[31] Foerster et al. (2011) report 0.19, 0.27, and 0.11 during the 1972 – 2007, 1972– 1983, and 1984 – 2007, respectively.

innovations depend on ρ_S and ω_S as follows.

$$\sigma_A = 0.005\sqrt{1-\omega_S} \quad \text{and} \quad \sigma_S = 0.005\sqrt{\frac{\omega_S}{2\phi^A\phi^B\left(1+\rho_S\right)}}.$$

As my benchmark calibration for impulse responses, I set $\omega_S = 0$. There is no industry-specific shocks. The reason is that I want to focus on propagation mechanisms endogenously derived from the slopping marginal cost curves and their variations. According to Foerster et al. (2011), the size of industry specific shocks is relatively small. They report $\omega_S = 0.11$ and 0.13 during the 1972 – 1983 and 1984 – 2007, respectively. Thus, I set $\omega_S = 0.12$ for simulated moments. There are no meaningful changes in all my results when I allow $\omega_S > 0$ in the reasonable range.

6.2 Impulse Responses: Cross-country and Cross-industry Resource Allocation

To investigate the cross-country and cross-industry resource allocation by international trade, this section shows the dynamic path of model variables based on numerical simulations in response to transitory shocks to productivity. To illustrate the model implications for sloping marginal costs and industry heterogeneity, I consider a transitory shock without spillover: $\xi_{AA} = \xi_{A^*A^*} = 0.9$ in Equation (56). Also, I set zero cross-country and cross-industry correlations: $\rho_C = \rho_S = 0$. There is no industry specific shock: $\omega_S = 0$. 84 $\%$ of the initial increase in productivity has been reabsorbed ten years after the shock approximately. The one-time transitory shock is favorable to home: 1% increase in $e_{A,t}$.

We consider the two models with heterogeneous and homogenous marginal cost structures denoted by Benchmark (the red lines) and GM (the blue lines), respectively. The benchmark model follows my benchmark calibration: $\alpha^A = 0.85$ and $\alpha^A = 1.15$. Industries A and B exhibit negative and positive within-firm market interdependence, respectively. The GM model has an identical flat marginal cost curve: $\alpha^A = \alpha^B = 1$ and represents the conventional new trade open macro model introduced by Ghironi and Melitz (2005). In both models, the entry friction is $\eta_E = 2.5$.

Figures 5 and 6 describe the impulse responses of aggregate and industrial variables to the home aggregate productivity shock, respectively. The impulses responses converge to the original steady states slowly because of endogenous firm entry with time to build and costs. After a favorable shock to the home country, Figure 5 shows that heterogeneous marginal costs generate more correlated business cycles. Increases in home and foreign GDP are smaller and larger in the Benchmark model than in the GM model, respectively. Further, Figure 6 indicates that industry outputs are more correlated across

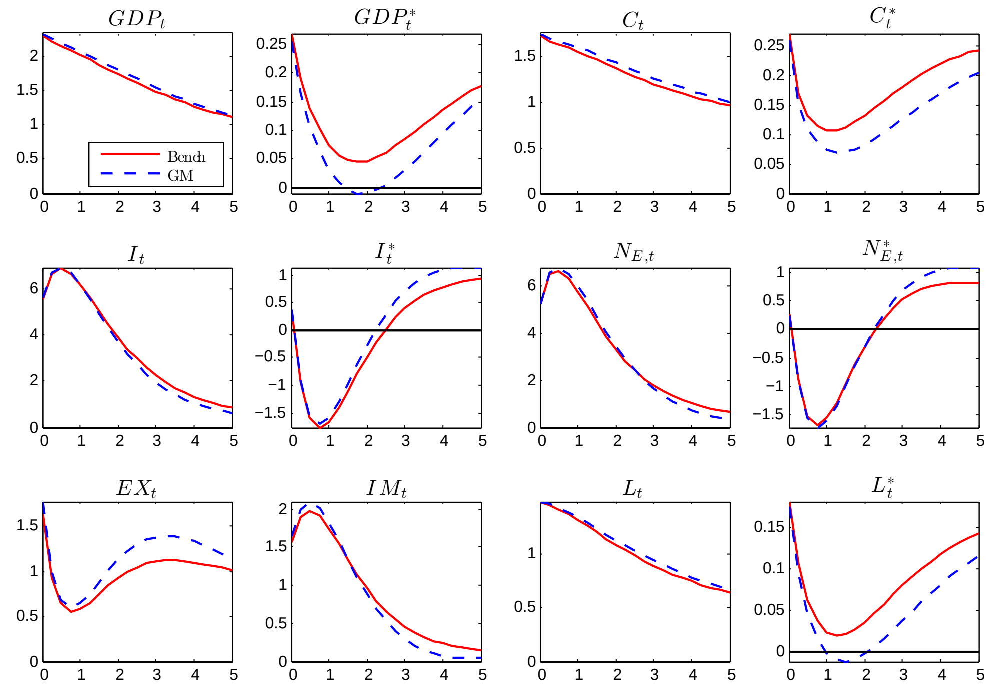

Figure 5: Impulse Responses to 1% aggregate shock in the Home Country: aggregate variables

Notes: The number of periods after the shock is on the horizontal axis. The percentage deviations from the steady state is on the vertical axis. The red lines and the blue dashed lines are the benchmark ($\alpha^A = 0.85$ and $\alpha^B = 1.15$) and GM ($\alpha^A = \alpha^B = 1$) models, respectively.

countries in Industry B than in Industry A. The home country is more concentrated in Industry A than in Industry B. The output, entry, and exports in the home Industry A increase more than them in the home Industry B. Since there is only aggregate shocks, the heterogeneous impulse responses of Benchmark model across industries are endogenous,and the responses of GM are identical across industries.

There are two main mechanisms generating the different responses between Industries A (circles) and B (squares) in Figure 6. First, economies of scale generate cost advantages for the home country in Industry B for both exporters and non-exporters. Since the number of firms is slowly changing, in the short run individual home firms expands after the shock occurs. Thus, Industry B with its decreasing marginal cost curve endogenously becomes more productive relative to Industry A, and Industry B expends more than Industry A. However, that scale channel disappears over time due to the large entry of home firms. An increase in the number of home firms implies that individual firm size decreases

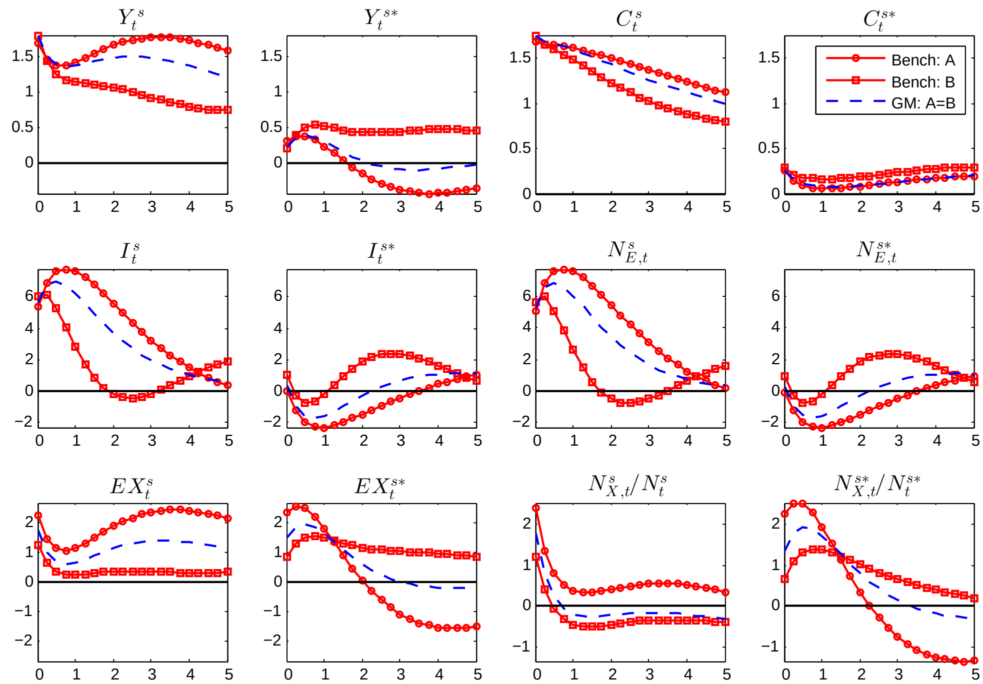

Figure 6: Impulse Responses to 1% aggregate shock in the Home Country: Industrial variables

Notes: The number of periods after the shock is on the horizontal axis. The percentage deviations from the steady state is on the vertical axis. The red lines and the blue dashed lines are the benchmark ($\alpha^A = 0.85$ and $\alpha^B = 1.15$) and GM ($\alpha^A = \alpha^B = 1$) models, respectively. The circles and squares are Industries A and B, respectively.

due to high competition, which means that home firms lose their cost advantages. Thus, the channel is negatively related to the speed of firm entry dynamics. The second channel works in the opposite direction. There are export losses and gains in Industries A and B, respectively. During a home boom, export gains are more important in the foreign country than in the home country due to low domestic demand in the foreign country relative to it in the home country. Thus, there are industry reallocations from Industry A to Industry B in the foreign country: more firms and exporters in Industry B. That channel is positively associated with the speed of firm entry dynamics.

The firm entry frictions play a crucial role in determining the size of these two channels. The first is more intensive and second more extensive. As the previous paragraph discussed, the first and second channel have a negative and positive association with firm entries, respectively. Slow changes in the number of firms strengthen the first channel but weaken the second channel. Under empirically plausible parameters, the first channel is larger than the second channel in the short run, but as time passes, the second channel overwhelms the first one. Thus, home Industry B expanses more than home Industry A at first. After one year, however, Industry A has a larger output than Industry B in the home country.

Figure 5 indicates that allowing heterogeneous marginal costs generates more correlated aggregate GDP comovements across countries. In Figure 6, the Benchmark model has larger cross-country differences in Industries A than the conventional model represented by GM, while the opposite is true for Industry B. Thus, Industry B contributes to mitigating the quantity anomaly. Conversely, Industry A worsens the quantity anomaly because within-firm market interdependence in Industries A and B are negative and positive, respectively. Positive within-firm market interdependence in Industry B is quantitatively larger than Industry A's negative interdependence because export gains and losses derived from marginal costs cause Industry B to trade more intensively than Industry A. Thus, industries with large economies of scale have larger impacts on international business cycles than industries with smaller economies of scale.

6.3 International Business Cycles

This section presents the international business cycle properties of the model. To calculate model-generated moments, I use HP filtered variables with a smoothing parameter of 1600 proposed by Hodrick and Prescott (1997).

For simulation, I define data-consistent variables using consumer price indices (CPIs) as in Ghironi and Melitz (2005). The data-consistent version of variables x_t and x_t^s (with welfare price indices, WPIs) are denoted $x_{R,t}$ and $x_{R,t}^s$, respectively. In my empirical analysis, I construct real variables for industries with industry-level price indices rather than the aggregate CPI. Thus, the industry's real variable with CPI is defined by

$$x_{R,t}^s = \left(N_t^s + N_{X,t}^{s*}\right)^{\frac{1}{1-\theta}} x_t^s.$$

$x_{R,t}^s$ ignores the love-of-variety effect from changes in the number of domestic and imported goods.[32]

[32] Alternatively, the industry's real variables can be defined by $x_{R,t}^s = \left[\phi^A \left(N_t^A + N_{X,t}^{A*}\right)^{\frac{1-\psi}{1-\theta}} + \phi^B \left(N_t^B + N_{X,t}^{B*}\right)^{\frac{1-\psi}{1-\theta}}\right]^{\frac{1}{1-\psi}} x_t^s$, which is based on the aggregate price index rather than the industry price index. There are no qualitative changes in my main simulation results between two methods constructing industry-level real variables.

The aggregate real variable with CPI is defined by

$$x_{R,t} = \left[\phi^A \left(N_t^A + N_{X,t}^{A*} \right)^{\frac{1-\psi}{1-\theta}} + \phi^B \left(N_t^B + N_{X,t}^{B*} \right)^{\frac{1-\psi}{1-\theta}} \right]^{\frac{1}{1-\psi}} x_t.$$

The recent open economy empirical papers have documented a very persistent shock (near unit root) with zero transmission across countries.[33] Thus, I use following very persistent process without spill-over: $\xi_{AA} = 0.99$ and $\xi_{AA^*} = 0$ in Equation (56). Since there is no productivity spill-over, cross-country comovements are due mainly to endogenous mechanisms. With spill-over as in Backus et al. (1992), foreign households expect increases in foreign productivity after home positive productivity shocks. Thus, the shock process with zero transmission $\xi_{AA^*} = 0$ generates lower consumption correlation between home and foreign countries than the shock process with spill-over: $\xi_{AA^*} > 0$.

Based on Ambler et al. (2004), I consider two cases. Case I represents twenty industrialized countries. Case II represents the U.S. and nine other countries – Australia, Austria, Canada, France, Germany, Italy, Japan, Switzerland, and the United Kingdom which I call the BKK sample. (Backus et al. (1992, 1995) use the sample.) International business cycles are more correlated in Case II than in Case I regarding GDP, consumption, labor, and productivity. Appendix A documents the details of the data set. In the models, there are only two industries. Thus, to match the coefficients $\hat{b}_1$ in Column (2) of Tables 5 – 6 and 8 – 9, I calculate slopes as follows. For variable x, its slope is defined by $\left(x^A - x^B\right) / \left(\ln \alpha^A - \ln \alpha^B\right)$ that quantifies the impacts of the sloping marginal cost curve on the variable x. In Cases I and II, the models with $\eta_E = 2$ and $\eta_E = 3$ approximately replicate the volatility of number of entrants in the U.S. data, respectively. Thus, I consider $\eta_E = \{2,\ 2.5,\ 3\}$.

The conventional international business cycle models assume the low correlation of shock innovations, which is 0.25 – 0.3. However, the recent empirical studies have found that the correlation is much lower than 0.25. Ambler et al. (2004) document the unweighted average of the BKK sample countries' correlation of the "Solow residual" measure of productivity (using only labor) with the U.S. as 0.25. Baxter and Farr (2005) document that the median of sample countries' correlations is 0.18 where they use both labor and capital.[34] I choose $\rho_C = 0.2$ in Case II. The unweighted average of pairwise cross-country correlations of productivity among twenty industrialized countries is 0.16 (using only labor) and 0.09 (using both labor and capital when available). I set $\rho_C = 0.1$ in Case I.

[33] See Baxter (1995) and Baxter and Farr (2005) for the details.

[34] Their sample countries are 10 OECD countries.

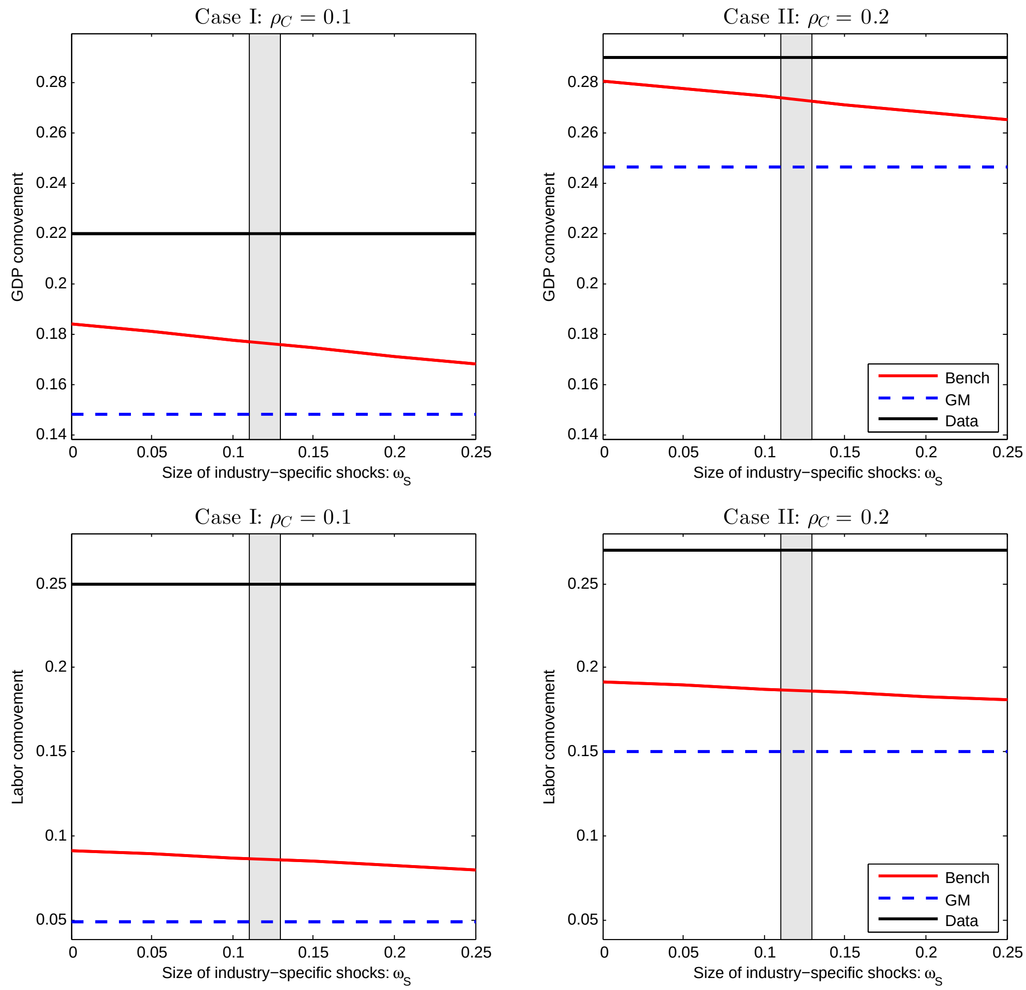

Figure 7: Cross-country GDP and Labor Comovement with Industry-specific Shocks

Notes: The red lines, the blue dashed lines, and the black lines are Benchmark ($\alpha^A = 0.85$ and $\alpha^B = 1.15$), GM ($\alpha^A = \alpha^B = 1$) models and the data of Ambler et al. (2004), respectively. The shaded area is the range of observed ω_S in Foerster, Sarte and Watson (2011). The friction of entry is $\eta_E = 2.5$.

6.3.1 Cross-Country Business Cycles

Canonical open macro models need additional positive interdependence channels to solve the quantity anomaly. Positive home productivity shocks directly promote new firm entry (or more investments in capital) in the home country due to high profits. The large entry with costs (or more investments in capital) induces cross-country resource shifts from the foreign country to the home country. The strong incentive for resource allocation to the more productive economy is why both standard international real business cycle model and new trade open macro models have low GDP comovements problems.

Figure 7 describes the impacts of marginal cost curve heterogeneity on cross-country correlations of GDP and labor. In both Case I and II, the models with heterogeneous sloping marginal cost curves better reproduce observed international comovements than the models with homogeneous flat marginal cost curves. As discussed in Section 6.2, industry heterogeneity of marginal costs yields more correlated GDP and labor across countries through within-firm market interdependence channels.

I consider the following range of industry-specific shocks: $\omega_S \in [0, 0.25]$. The shocks directly make a more productive economy more concentrated in industries where a favorable industry-specific shock is realized. Thus, the industry-specific shocks can dampen our model's propagation mechanisms generating GDP comovements. Figure 7 describes the relationship between GDP comovements and industry-specific shocks. My shock process are constructed in such a way that the size of industry-specific shocks have no effect on the second moments of model with identical industries. Thus, the blue dashed lines (GM model) are straight. The red lines illustrate that introducing industry-specific shocks in the model with different cost structures across industries worsen discrepancy between theory and data related to cross-country comovements of GDPs. However, the benchmark model is better than the model with homogenous flat marginal cost curves even though there are sizable industry-specific shocks.

Figure 8 illustrates the impacts of the aggregate slope of marginal cost curves on GDP comovements. According to my estimation results, the weighted average of α in the US manufacturing industries is between 1.068 and 1.254.[35] In the US economy, the size of manufacturing industries is around 12% (valued added % of GDP). If the other industries face no economies of scale (constant returns to scale), then the aggregate US economy's marginal cost coefficient is between 1.01 and 1.03. To get these number in my model, the range of the size of Industry B, ϕ^B, is 0.53 – 0.61. Decreasing and increasing marginal cost curves generate positive and negative within-firm level interdependence, which increase and decrease comovements across domestic and export markets, respectively. Thus, a large size of Industry B implies strongly correlated GDPs and labors across countries.

6.3.2 Within-country International Business Cycles

The results of my simulations are summarized in Table 12. Panel A and B report my model's aggregate- and industry- level international business cycle properties, respectively. In each case, I report the low, medium, and high entry frictions for both conventional (GM) models with identical flat marginal cost curves and Benchmark models with heterogeneous sloping marginal cost curves. The results of Cases

[35] See Table 1 and A2 for the results of i) instrumented vs uninstrumented and ii) benchamrk vs alternative.

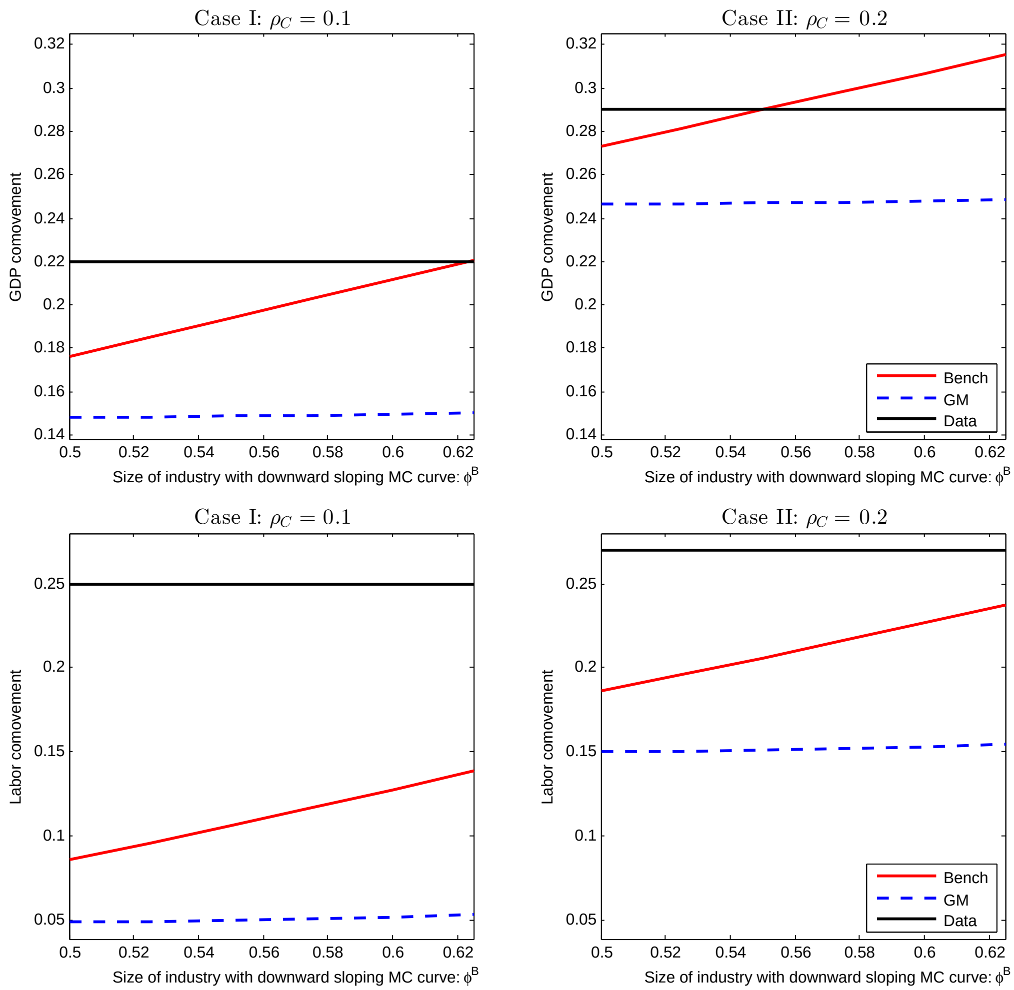

Figure 8: Cross-country GDP and Labor Comovement over Economies of Scale

Notes: The horizontal axis is the size of industry with downward sloping marginal cost curves: ϕ^B. Since $\alpha^A < \alpha^B$, $\phi^B > 0.5$ causes the aggregated marginal cost curve to be downward sloping, which implies economies of scale in the aggregate economy. The red lines, the blue dashed lines, and the black lines are Benchmark ($\alpha^A = 0.85$ and $\alpha^B = 1.15$), GM ($\alpha^A = \alpha^B = 1$) models and the data of Ambler et al. (2004), respectively. The size of industry-specific shocks is $\omega_S = 0.12$. The friction of entry is $\eta_E = 2.5$

I and II are indistinguishable except for cyclicality of exports, which implies that cross-country shock correlations have limited effects on aggregate variables' dynamics and second moments.

The first and second parts of Panel A in Table 12 describe the volatilities of the aggregate macro and trade flows, where allowing industry cost heterogeneity plays a minor role. The model overpredicts the standard deviation (relative to aggregate GDP) of consumption and labor and underpredicts that of exports and imports. Although the model successfully generates less volatile consumption than GDP,

Table 12: International Business Cycle (within-country): Data and Simulated Moments

	US Data	Case I: $\rho_C = 0.1$						Case II: $\rho_C = 0.2$					
		GM			Benchmark			GM			Benchmark		
	η_E	2	2.5	3	2	2.5	3	2	2.5	3	2	2.5	3
Panel A: Aggregate-level International Business Cycle													
Volatility: standard deviation %													
GDP	1.54	1.57	1.56	1.55	1.51	1.50	1.50	1.57	1.57	1.56	1.52	1.51	1.51
Volatility: standard deviation relative to GDP													
Consumption	0.82	0.97	0.97	0.97	0.96	0.96	0.97	0.96	0.97	0.97	0.96	0.96	0.96
Investment	4.20	3.81	3.68	3.57	3.60	3.48	3.36	3.62	3.50	3.39	3.42	3.30	3.19
Labor	0.62	0.73	0.72	0.72	0.74	0.73	0.73	0.72	0.72	0.71	0.73	0.73	0.73
Export	2.64	1.91	1.87	1.83	1.67	1.64	1.61	1.87	1.84	1.80	1.65	1.62	1.60
Import	3.14	1.81	1.78	1.75	1.57	1.54	1.52	1.78	1.76	1.73	1.56	1.54	1.52
# of Entrants	3.28	3.83	3.70	3.59	3.59	3.48	3.38	3.64	3.52	3.40	3.41	3.31	3.22
Cyclicality: correlation to GDP													
Consumption	0.86	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Investment	0.91	0.78	0.78	0.77	0.79	0.79	0.78	0.77	0.77	0.77	0.78	0.78	0.78
Labor	0.81	1.00	1.00	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	0.99
Export	0.29	0.06	0.09	0.12	0.14	0.18	0.21	0.15	0.18	0.21	0.24	0.27	0.30
Import	0.75	0.89	0.90	0.90	0.93	0.93	0.93	0.90	0.91	0.91	0.94	0.94	0.94
# of Entrants	0.58	0.78	0.77	0.77	0.79	0.79	0.79	0.77	0.77	0.77	0.79	0.79	0.78
Panel B: Industry-level International Business Cycle													
Volatility: Slope of log percent standard deviation													
Output	0.73				0.21	0.30	0.37				0.24	0.32	0.38
Volatility: Slope of log standard deviation relative to industry output													
Export	-0.52				-6.68	-6.74	-6.75				-6.50	-6.55	-6.54
Import	-0.69				-6.12	-6.08	-6.01				-5.92	-5.88	-5.82
Cyclicality: Slope of correlation to GDP													
Output	0.23				0.44	0.41	0.38				0.38	0.35	0.33
Export	0.37				0.02	0.12	0.20				0.04	0.13	0.20
Import	0.26				0.35	0.27	0.20				0.32	0.24	0.18

Notes: All variables are HP filtered. The aggregate US data statistics are quarterly and seasonally adjusted. The aggregate-level US quarterly data is from Federal Reserve Economic Data except for the number of entrants. The sample period is from 1960:q1 to 2000:q4, that is the same as in Ambler et al. (2004). The number of entrants data are from private sector establishment births in Bureau of Labor Statistics database. The sample period is from 1993:q2 to 2016:q4. The relative standard deviation of number of entrants is relative to standard deviation GDP from 1993:q2 to 2016:q4. The industry-level data are from Section 3. The slopes are the coefficients of economies of scale derived from marginal costs in regressions. (See Column (2) in Tables 5 – 6 and 8 – 9 for the details.)

the standard deviation (relative to aggregate GDP) of consumption is larger than in the data. That is because a near-unit root shock without spill-over and GHH preference lowers consumption smoothing.

Thus, consumption becomes very persistent and volatile.[36] In the model, exports and imports have very similar standard deviations, and they are smaller than in the U.S. data. As in Ghironi and Melitz (2005), an individual firm's export decision depends on fixed export costs. For tractability, I omit sunk export cost. While Alessandria and Choi (2007) find that the export cost structure in models plays a limited role in business cycle patterns of net exports, introducing sunk export costs would generate more persistent export and import flows. Thus, adding sunk export costs would be helpful to correct the low volatilities of trade flows. More importantly, the model fails to reproduce the larger volatility of imports than that of exports. In the model, extensive margins are more important in exports than in imports, but intensive margins are more important in imports than in exports. Since the number of firms changes slowly, the export process is more persistent than the import process. Thus, exports have a relatively large standard deviation in the model.

The last part of Panel A reports cyclical properties within a country. All models successfully reproduce the observed patterns that imports are more procyclical than exports in which cost heterogeneity and entry frictions play a vital role. First, allowing industry cost heterogeneity enhances the model's ability to reproduce quantitatively better cyclical patterns of export. In both Cases I and II, the models with homogeneous industries tend to generate weakly procyclical exports, which is one of the problems in GM models. Heterogeneous sloping marginal cost curves in Benchmark models make exports more procyclical – more consistent with the data – than in models with a homogeneous linear cost function through a within-firm market interdependence channel. Second, models with larger entry frictions reproduce more procylical exports and imports than models with smaller entry frictions. During a boom, great firm entry implies large terms of labor appreciation (high costs in the more productive economy). Thus, firms loose their competitiveness in both domestic and export markets due to high production costs. Firm entry frictions mitigate these extensive margin channels. This mechanism explains why entry frictions increase the procyclicality of trade flows in new trade open macro models regardless of cost structure.

In the data, consumption and labor are strongly procyclical. In Panel A, all models generate more strongly correlated consumption and labor to GDP than the data. Indeed, correlations with GDP are near perfect in the model. As discussed above, a near unit root shock lowers consumption smoothing. Thus, consumption moves in the same direction as income (GDP). For tractability, a representative household supplies labor. This and the GHH preference imply that labor supply depends only on wages. Hence,

[36] See Ghironi and Melitz (2005) for differences between a near-unit root shock without spill-over and a persistent shock with spill-over introduced by Backus et al. (1992). See Raffo (2008) for details of GHH preference in international business cycle models.

labor is very strongly correlated to GDP.

Panel B in Table 12 illustrates how properties of heterogeneous international business cycles across industries change when I vary the firm entry friction. My models with plausible entry frictions capture the qualitative patterns in the six-digit NAICS U.S. manufacturing industries. Section 3 documents that volatility of exports and imports decreases, but that of output increases in economies of scale derived from marginal costs. Further, industry output, exports, and imports are more procyclical in industries with large α than in industries with small α. The results of Case I and II are quantitatively very similar and qualitatively equivalent, which implies that cross-country shock correlations have no major effect on industry-level business cycle properties. Despite success at reproducing the qualitative patterns of the industry-level business cycle, the models are less successful from the quantitative perspectives. My empirical analysis reported in Column (2) of Tables 5 – 7 and 8 – 9 indicate that the models with $\eta_E = 2.5$ and 3 succeed in generating the slopes of cyclicality measures of output, exports, and imports. However, all models fail to generate the slopes of volatility measures within the 99% confidence intervals. These quantitative failures could be caused by the simplicity of the model. The model contains only two industries, and uses only aggregate productivity shock.

During a home boom, cost advantages due to economies of scale increase Industry B's output more than Industry A's output. Thus, industries with large α have more volatile and procyclical output than do industries with small α. In industries with decreasing marginal costs (Industry B), world demands are relatively more important than in industries with increasing marginal costs (Industry A) because domestic and export market demands are complements and substitute in industry B and A, respectively. Thus, international goods trade dampens demand channels of domestic shocks in Industry B, but amplifies in Industry A. Hence, exports and imports are fluctuated less in Industry B than in Industry A. That channel serves to lower the slope of the output volatility measure in the models.

Section 6.2 explains why Industry A has less procyclical production than Industry B. The models reproduce the empirical observation that the slope of the export cyclicality measure increases in entry frictions. As I discussed in Section 6.2, there are two channels: cost advantages and export gains. During a home boom, the cost advantage channel increases exports in Industry B relative to Industry A, and is large when firms enter slowly. The export gain channel generates incentives for the home country to be concentrated in Industry A rather than Industry B, which depends on reallocations of firms across industries. Hence, increasing entry frictions causes the first channel to dominate the second channel. These channels affect imports in the opposite way. The slopes of the cyclicality of exports and imports increases and decreases in entry frictions, respectively.

7 Concluding Remarks

An important question in international trade and macroeconomics has been a role of economies of scale. However, formal international macroeconomy models generally neglect their sources. This paper distinguishes economies of scale into sloping marginal cost curves and nonproduction costs. I find that they are differently associated with aggregate and industrial international business cycle fluctuations. These results are intuitive because a flat marginal cost curve makes the domestic and export profits to be linearly separable. Thus, there is no within-firm link between domestic demand and exports even a firm serves in both domestic and export markets. However, a sloping marginal cost curve breaks the separability. It causes that firm's decisions in one market change its marginal costs of production that have impacts on its decisions in the other market, which play a role as cross-industry and cross-country transmission mechanisms.

I provide, first, a method to estimate the slopes of marginal cost curves. My approach relies on cost minimization, free entry condition, and frictions. In the U.S., the slopes are related to the business cycle properties of output, exports, and imports across narrowly defined industries. Second, I provide a framework to study the marginal cost heterogeneity and its implications for the industry- and aggregate-level dynamics. The within-firm market interdependence across domestic and export markets that arises from different slopes enhances the internal propagation mechanisms of the model. The calibrated model reproduces the industry-level business cycles that are consistent with the U.S. industry-level data. Also, it delivers more strongly correlated business cycles across countries I interpret these findings as evidence that sloping marginal cost curves and their variations across industries improve our understanding of the international business cycle.

References

Alessandria, George and Horag Choi (2007), ‘Do sunk costs of exporting matter for net export dynamics?’, *The Quarterly Journal of Economics* **122**(1), 289–336.
URL: + *http://dx.doi.org/10.1162/qjec.122.1.289*

Almunia, Miguel, Pol Antras, David Lopez-Rodriguez and Eduardo Morales (2018), Venting out: Exports during a domestic slump, mimeo.

Ambler, Steve, Emanuela Cardia and Christian Zimmermann (2002), ‘International transmission of the business cycle in a multi-sector model’, *European Economic Review* **46**(2), 273 – 300.
URL: *http://www.sciencedirect.com/science/article/pii/S0014292101000988*

Ambler, Steve, Emanuela Cardia and Christian Zimmermann (2004), ‘International business cycles: What are the facts?’, *Journal of Monetary Economics* **51**(2), 257 – 276.
URL: *http://www.sciencedirect.com/science/article/pii/S0304393203001417*

Antweiler, Werner and Daniel Trefler (2002), ‘Increasing returns and all that: A view from trade’, *The American Economic Review* **92**(1), 93–119.
URL: *http://www.jstor.org/stable/3083323*

Axtell, Robert L. (2001), ‘Zipf distribution of u.s. firm sizes’, *Science* **293**(5536), 1818–1820.
URL: *http://science.sciencemag.org/content/293/5536/1818*

Backus, David K., Patrick J. Kehoe and Finn E. Kydland (1992), ‘International real business cycles’, *Journal of Political Economy* **100**(4), 745–75.
URL: *http://EconPapers.repec.org/RePEc:ucp:jpolec:v:100:y:1992:i:4:p:745-75*

Backus, David K., Patrick J. Kehoe and Finn E. Kydland (1994), ‘Dynamics of the trade balance and the terms of trade: The j-curve?’, *The American Economic Review* **84**(1), 84–103.
URL: *http://www.jstor.org/stable/2117972*

Backus, David, Patrick Kehoe and Finn Kydland (1995), International business cycles: Theory and evidence, *in* T. F.Cooley, ed., ‘Frontiers of Business Cycle Research’, Princeton University Press, Princeton, NJ, pp. 331 – 356.

Baily, Martin Neil, Charles Hulten, David Campbell, Timothy Bresnahan and Richard E. Caves (1992), ‘Productivity dynamics in manufacturing plants’, *Brookings Papers on Economic Activity. Microeconomics* **1992**, 187–267.
URL: *http://www.jstor.org/stable/2534764*

Bartelsman, Eric J. and Wayne Gray (1996), The nber manufacturing productivity database, Working Paper 205, National Bureau of Economic Research.
URL: *http://www.nber.org/papers/t0205*

Basu, Susanto and John G. Fernald (1997), ‘Returns to scale in u.s. production: Estimates and implications’, *Journal of Political Economy* **105**(2), 249–283.
URL: *http://www.jstor.org/stable/10.1086/262073*

Basu, Susanto, John G. Fernald and Miles S. Kimball (2006), 'Are technology improvements contractionary?', *The American Economic Review* **96**(5), 1418–1448.
URL: *http://www.jstor.org/stable/30034981*

Baxter, Marianne (1995), Chapter 35 international trade and business cycles, Vol. 3 of *Handbook of International Economics*, Elsevier, pp. 1801 – 1864.
URL: *http://www.sciencedirect.com/science/article/pii/S1573440405800152*

Baxter, Marianne and Dorsey D. Farr (2005), 'Variable capital utilization and international business cycles', *Journal of International Economics* **65**(2), 335 – 347.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199604000686*

Berman, Nicolas, Antoine Berthou and Jerome Hericourt (2015), 'Export dynamics and sales at home', *Journal of International Economics* **96**(2), 298 – 310.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199615000653*

Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen and Samuel Kortum (2003), 'Plants and productivity in international trade', *The American Economic Review* **93**(4), 1268–1290.
URL: *http://www.jstor.org/stable/3132288*

Bhattarai, Saroj and Konstantin Kucheryavyy (2018), A unified model of international business cycles and trade, 2018 Meeting Papers 1259, Society for Economic Dynamics.
URL: *https://EconPapers.repec.org/RePEc:red:sed018:1259*

Bilbiie, Florin O., Fabio Ghironi and Marc J. Melitz (2012), 'Endogenous entry, product variety, and business cycles', *Journal of Political Economy* **120**(2), 304–345.
URL: *https://doi.org/10.1086/665825*

Burnside, Craig (1996), 'Production function regressions, returns to scale, and externalities', *Journal of Monetary Economics* **37**(2), 177 – 201.
URL: *http://www.sciencedirect.com/science/article/pii/S0304393296900331*

Chang, Yongsung and Jay H. Hong (2006), 'Do technological improvements in the manufacturing sector raise or lower employment?', *The American Economic Review* **96**(1), 352–368.
URL: *http://www.jstor.org/stable/30034370*

De Loecker, Jan and Frederic Warzynski (2012), 'Markups and firm-level export status', *American Economic Review* **102**(6), 2437–71.
URL: *http://www.aeaweb.org.offcampus.lib.washington.edu/articles.php?doi=10.1257/aer.102.6.2437*

De Loecker, Jan, Pinelopi K. Goldberg, Amit K. Khandelwal and Nina Pavcnik (2016), 'Prices, markups, and trade reform', *Econometrica* **84**(2), 445–510.
URL: *http://dx.doi.org/10.3982/ECTA11042*

Devereux, Michael B., Allen C. Head and Beverly J. Lapham (1996), 'Aggregate fluctuations with increasing returns to specialization and scale', *Journal of Economic Dynamics and Control* **20**(4), 627 – 656.
URL: *http://www.sciencedirect.com/science/article/pii/0165188995008683*

di Giovanni, Julian, Andrei A. Levchenko and Isabelle Mejean (2016), The micro origins of international business cycle comovement, Working Paper 21885, National Bureau of Economic Research.
URL: *http://www.nber.org/papers/w21885*

Fattal-Jaef, Roberto N. and Jose Ignacio Lopez (2014), 'Entry, trade costs, and international business cycles', *Journal of International Economics* **94**(2), 224 – 238.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199614001019*

Foerster, Andrew T., Pierre-Daniel G. Sarte and Mark W. Watson (2011), 'Sectoral versus aggregate shocks: A structural factor analysis of industrial production', *Journal of Political Economy* **119**(1), 1–38.
URL: *https://doi.org/10.1086/659311*

Ghironi, Fabio and Marc J. Melitz (2005), 'International trade and macroeconomic dynamics with heterogeneous firms', *The Quarterly Journal of Economics* **120**(3), 865–915.
URL: *http://qje.oxfordjournals.org/content/120/3/865.abstract*

Greenwood, Jeremy, Zvi Hercowitz and Gregory W. Huffman (1988), 'Investment, capacity utilization, and the real business cycle', *The American Economic Review* **78**(3), 402–417.
URL: *http://www.jstor.org/stable/1809141*

Hamilton, James D. (2003), 'What is an oil shock?', *Journal of Econometrics* **113**(2), 363 – 398.
URL: *http://www.sciencedirect.com/science/article/pii/S0304407602002075*

Harrigan, James (1994), 'Scale economies and the volume of trade', *The Review of Economics and Statistics* **76**(2), 321–328.
URL: *http://www.jstor.org/stable/2109886*

Harrison, Sharon G. (2003), 'Returns to scale and externalities in the consumption and investment sectors', *Review of Economic Dynamics* **6**(4), 963 – 976. Finance and the Macroeconomy.
URL: *http://www.sciencedirect.com/science/article/pii/S1094202503000346*

Head, Allen C. (2002), 'Aggregate fluctuations with national and international returns to scale*', *International Economic Review* **43**(4), 1101–1125.
URL: *http://dx.doi.org/10.1111/1468-2354.t01-1-00050*

Heathcote, Jonathan and Fabrizio Perri (2002), 'Financial autarky and international business cycles', *Journal of Monetary Economics* **49**(3), 601 – 627.
URL: *http://www.sciencedirect.com/science/article/pii/S0304393202001034*

Hodrick, Robert J. and Edward C. Prescott (1997), 'Postwar u.s. business cycles: An empirical investigation', *Journal of Money, Credit and Banking* **29**(1), 1–16.
URL: *http://www.jstor.org/stable/2953682*

Hornstein, Andreas (1993), 'Monopolistic competition, increasing returns to scale, and the importance of productivity shocks', *Journal of Monetary Economics* **31**(3), 299 – 316.
URL: *http://www.sciencedirect.com/science/article/pii/030439329390050P*

Kehoe, Patrick J. and Fabrizio Perri (2002), 'International business cycles with endogenous incomplete markets', *Econometrica* **70**(3), 907–928.
URL: *http://dx.doi.org/10.1111/1468-0262.00314*

Kim, Jinill (2004), 'What determines aggregate returns to scale?', *Journal of Economic Dynamics and Control* **28**(8), 1577 – 1594.
URL: *http://www.sciencedirect.com/science/article/pii/S0165188903000964*

Kose, M. Ayhan and Kei-Mu Yi (2001), 'International trade and business cycles: Is vertical specialization the missing link?', *The American Economic Review* **91**(2), 371–375.
URL: *http://www.jstor.org/stable/2677791*

Kose, M. Ayhan and Kei-Mu Yi (2006), 'Can the standard international business cycle model explain the relation between trade and comovement?', *Journal of International Economics* **68**(2), 267 – 295.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199605000590*

Krugman, Paul R. (1979), 'Increasing returns, monopolistic competition, and international trade', *Journal of International Economics* **9**(4), 469 – 479.
URL: *http://www.sciencedirect.com/science/article/pii/0022199679900175*

Krugman, Paul R. (1980), 'Scale economies, product differentiation, and the pattern of trade', *The American Economic Review* **70**(5), 950–959.
URL: *http://www.jstor.org/stable/1805774*

Lee, Yoonsoo (2007), The importance of reallocations in cyclical productivity and returns to scale: Evidence from plant-level data, Working papers, U.S. Census Bureau, Center for Economic Studies.
URL: *http://EconPapers.repec.org/RePEc:cen:wpaper:07-05*

Lyn, Gary and Andres Rodriguez-Clare (2013), 'External economies and international trade redux: Comment*', *The Quarterly Journal of Economics* **128**(4), 1895–1905.
URL: + *http://dx.doi.org/10.1093/qje/qjt017*

Melitz, Marc J. (2003), 'The impact of trade on intra-industry reallocations and aggregate industry productivity', *Econometrica* **71**(6), 1695–1725.
URL: *http://dx.doi.org/10.1111/1468-0262.00467*

Nelson, Charles R. and Richard Startz (1990), 'Some further results on the exact small sample properties of the instrumental variable estimator', *Econometrica* **58**(4), 967–976.
URL: *http://www.jstor.org/stable/2938359*

Pierce, Justin and Peter K. Schott (2009), A concordance between ten-digit u.s. harmonized system codes and sic/naics product classes and industries, NBER Working Papers 15548, National Bureau of Economic Research, Inc.
URL: *http://EconPapers.repec.org/RePEc:nbr:nberwo:15548*

Raffo, Andrea (2008), 'Net exports, consumption volatility and international business cycle models', *Journal of International Economics* **75**(1), 14 – 29.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199607001158*

Rebelo, Sergio (2005), 'Real business cycle models: Past, present and future', *The Scandinavian Journal of Economics* **107**(2), 217–238.
URL: *http://www.jstor.org/stable/3441103*

Rho, Youngwoo and Joel Rodrigue (2016), 'Firm-level investment and export dynamics*', *International Economic Review* **57**(1), 271–304.
URL: *http://dx.doi.org/10.1111/iere.12156*

Rotemberg, Julio J. and Michael Woodford (1995), Chapter 9 dynamic general equilibrium models with imperfectly competitive product markets, *in* T. F.Cooley, ed., 'Frontiers of Business Cycle Research', Princeton University Press, pp. 243 – 293.

Schott, Peter K. (2008), 'The relative sophistication of chinese exports', *Economic Policy* **23**(53), 5–49.
URL: *http://www.jstor.org/stable/40071830*

Soderbery, Anson (2014), 'Market size, structure, and access: Trade with capacity constraints', *European Economic Review* **70**, 276 – 298.
URL: *http://www.sciencedirect.com/science/article/pii/S0014292114000890*

Stock, James H. and Mark W. Watson (1999), Chapter 1 business cycle fluctuations in us macroeconomic time series, Vol. 1 of *Handbook of Macroeconomics*, Elsevier, pp. 3 – 64.
URL: *http://www.sciencedirect.com/science/article/pii/S1574004899010046*

Tybout, James R. (1993), 'Internal returns to scale as a source of comparative advantage: The evidence', *The American Economic Review* **83**(2), 440–444.
URL: *http://www.jstor.org/stable/2117705*

Vannoorenberghe, G. (2012), 'Firm-level volatility and exports', *Journal of International Economics* **86**(1), 57 – 67.
URL: *http://www.sciencedirect.com/science/article/pii/S0022199611001097*

Appendix

A Data and Measurement

A.1 Cost Share-weighted Growth Rate in Total, Production, Nonproduction Inputs

I construct the cost share-weighted growth rate in total inputs as in the previous literature. The zero profit implies that the value of the shipment is the total cost. The capital input is real in the data. The material input is the material cost divided by the price index. The total labor input is measured as the total hours for production and nonproduction workers. Because the database does not cover hours for nonproduction workers, the value for total hours is estimated following the method used in Baily, Hulten, Campbell, Bresnahan and Caves (1992). I use averaged production labor and material cost shares in the total cost over the beginning and ending years of the period of change. The capital cost share is calculated by the remaining part of the sum of production labor and material cost shares. Also, I construct the cost share-weighted growth rate in production and nonproduction inputs. The total hours for production workers measure the production labor input. The ratio of nonproduction input to production input for labor is calculated by the ratio of payroll for nonproduction workers to payroll for production workers. The data contain the real capital and material but do not distinguish the production and nonproduction capital. Thus, I assume that the ratio of nonproduction inputs to production inputs for capital and material equals the ratio of nonproduction labor to production labor. The total production cost is the sum of costs of production labor, capital, and material inputs. As in the above way constructing the cost share-weighted growth rate in total inputs, the capital cost share in the total cost is constructed by as the remaining part of the sum of production labor and material cost shares in the production cost.

A.2 Industry-level Macro and Trade Data: U.S. Manufacturers

A.2.1 Cost Structure Estimation

A data frequency is annual. I collect industry-level data in NBER-CES Manufacturing Industry Database from 1958 to 2011.(See Bartelsman and Gray (1996) for the details.) I use the NAICS version.

Output I use the value of shipments deflated by the shipments deflator from the BEA.

Capital Input I use the real capital stock.

Labor Input The labor input is not actually correlated. The benchmark follows Baily et al. (1992). The alternative uses the production workers' hours.

Material Input I use the cost of materials deflated by the material cost deflator calculated using data from the benchmark use-make (input-output) tables and the GDP-by-Industry data of the BEA.

A.2.2 International Business Cycle Estimation

A data frequency is annual. All variables are logarithmic and HP-filtered with parameter 6.25.

I construct the six-digit NAICS level U.S. export and import flows from following bilateral trade data between the U.S. and its trading partners. I correct the bilateral trade data in Schott (2008). Schott (2008) provides HS-level U.S. imports and exports data from 1989 to 2011. I convert the data to six digit NAICS by using Pierce and Schott (2009).

Exports I use the exports deflated by the shipments deflator from the BEA.

Imports I use the c.i.f imports deflated by the shipments deflator from the BEA.

The delator is corrected from the NBER-CES Manufacturing Industry Database, which does not cover the following industries: their six digit NAICS codes are 31131X, 31181X, 31511X, 32531X, 33631X, and 33641X. In these case, I use the average price deflator of industries with the same five digit NAICS group. 31131X: average of 311311–3. 31181X: average of 311811–3. 31511X: average of 315111 and 315119. 32531X: average of 325311–2 and 325314. 33631X: average of 336311–2. 33641X: average of 336411–5 and 336419.

A.3 Aggregate U.S. Variables

The data frequency is quarterly. I use seasonally adjusted variables. All variables are logarithmic and HP filtered with a smoothing parameter of 1600.

I collect aggregate GDP, consumption, investment, exports, imports, and labor data in Federal Reserve Economic Data (FRED). The sample period is from 1960:q1 to 2000:q4 to match Ambler et al. (2004).

GDP GDPC1: Real Gross Domestic Product, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate

Consumption PCECC96: Real Personal Consumption Expenditures, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate

Investment GPDIC1: Real Gross Private Domestic Investment, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate

Exports EXPGSC1: Real Exports of Goods and Services, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate

IMPGSC1 EXPGSCA: Real imports of goods and services, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate

The number of entrants data is from private sector establishment births in BLS database. The sample period is from 1993:q2 to 2017:q4. When calculating its standard deviation relative to GDP and correlation to GDP, I use the real aggregate GDP from 1993:q2 to 2017:q4.

Number of Entrants I use private sector establishment births.

A.4 Cross-country Correlations

The data frequency is quarterly. International comovements data in Table **??** are from Table 5 and 1 in Ambler et al. (2004). First, Data I is from the first column of Table 1 in Ambler et al. (2004) that is the average cross-correlation for 20 countries during the sample period from 1960:q1 to 2000:q4. The twenty countries in the sample are Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States. Second, Data II is from the results for the unweighted average of nine countries in Table 5 in Ambler et al. (2004) where the nine countries are: Australia, Austria, Canada, France, Germany, Italy, Japan, Switzerland, and the United Kingdom. The sample is from 1960:q1 to 2000:q4.

B Instruments: Production Function Estimation

I use the following variables and their one-year lags.

Oil price shocks I collect monthly spot crude oil price: West Texas Intermediate (WTI) from FRED. As in Hamilton (2003), I construct the proxy of oil shocks by using the value of the oil price at time t relative to its largest value over the preceding 12 months: $\max\left\{0, \ln \text{Oil price}_t - \ln \text{Oil price}^{max}_{t-12,t-1}\right\}$ where $\text{Oil price}^{max}_{t-12,t-1}$ is the highest price of oil from $t-12$ and $t-1$. I use the real price of WTI (based on CPI). The annual oil price shocks are the sum of the monthly shocks.

Growth rate of government defense spending A489RA3A086NBEA from FRED: Real federal government consumption expenditures: Defense consumption expenditures: Gross output of general government: Intermediate goods and services purchased: Services (chain-type quantity index), Index 2009=100, annual

Monetary policy shocks The measure of monetary shocks is based on a monthly VAR model including the following log variables and 12 lags: the industrial production, the unemployment rate, the log of the CPI, and the log of a commodity price index, the federal funds rate, and M1. All data are from FRED. The error term from the fitted policy rule is the measure of the monetary shocks. The annual shocks are the sum of the monthly shocks. Exogenous time dummies, excluding the unemployment, and using T-bill interest rate instead of the federal fund rate have no impact on the results.

President's party

C Dropping Procedure

When I estimate the cost structure of industries, I drop some industries as follows. I drop 315211 and 315212 because calculated capital costs are negative in many years.[37] I remove industries (311811, 326212, 334611, and 339116) that have zero value of shipments (no observation) at least once across the sample period: making the balanced sample.

For each estimation, I drop negative value of γ_R, $\gamma_{y,R}$, α, and ϵ. Additionally, I drop the estimated value as follows.

- Benchmark
  - α is negative: I drop γ_R, $\gamma_{y,R}$, and α.
- Alternative
  - γ_R is negative: I drop γ_R, α, and ϵ.
  - $\gamma_{y,R}$ is negative: I drop $\gamma_{y,R}$, α, and ϵ.
  - I remove when α is larger than 5, which only happens when I use the alternative method. The main drawback of the alternative is that α is sensitive when ϵ is closed to one.

[37] Data do not provide the capital costs, thus I use total costs minus other costs.

D Figures

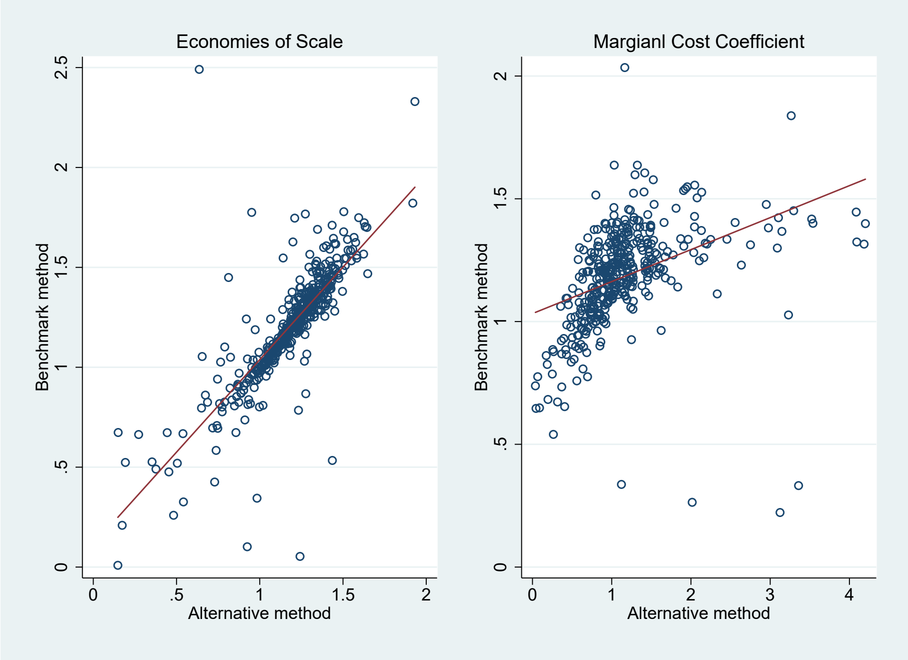

Figure A1: Benchmark and Alternative Methods

Notes: The red lines are the fitted values by using OLS regressions.

E Tables

Table A1: Relationship between Production and Nonproduction Inputs

	Short-run: 1 Year Growth				Long-run: 10 Year Growth			
	Unweighted		Weighted		Unweighted		Weighted	
Correlation	Mean	Median	Mean	Median	Mean	Median	Mean	Median
$\Delta f(\mathbf{X}_y)$ and $\Delta f(\mathbf{X}_{\text{fc}})$	0.418	0.472	0.468	0.560	0.705	0.808	0.729	0.831

Notes: The number of observations is 467 industries. For the weighted results I use the over-time average of industry's fraction of unfiltered nominal value of shipments: $\text{weight}^s_{PY} = (1/T)[\sum_t (P^s_t Y^s_t / \sum_{s'} P^{s'}_t Y^{s'}_t)]$.

Table A2: Unweighted Estimated Cost Structures

	Total			SEOS			LEOS		
	Mean	Median	Obs.	Mean	Median	Obs.	Mean	Median	Obs.
Panel A: Uninstrumented GMM									
Benchmark: Equation (21)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.645	0.540	467	0.663	0.525	233	0.629	0.543	228
γ_R	1.208	1.237	461	1.061	1.078	233	1.359	1.338	228
$\gamma_{y,R}$	1.086	1.081	458	1.025	1.027	225	1.141	1.127	228
α	1.160	1.198	466	1.023	1.061	233	1.304	1.287	228
Alternative: Equations (22) and (23)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.645	0.540	467	0.654	0.521	216	0.636	0.546	250
γ_R	1.182	1.223	466	1.017	1.059	216	1.324	1.309	250
$\gamma_{y,R}$	0.952	0.992	466	0.812	0.845	216	1.073	1.085	250
α	1.158	1.031	401	0.876	0.780	168	1.361	1.194	233
Panel B: Instrumented GMM									
Benchmark: Equation (21)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.645	0.540	467	0.668	0.543	247	0.620	0.534	200
γ_R	1.363	1.269	447	1.286	1.080	247	1.458	1.408	200
$\gamma_{y,R}$	1.135	1.094	450	1.061	1.028	241	1.205	1.164	200
α	1.199	1.201	461	1.054	1.071	247	1.404	1.351	200
Alternative: Equations (22) and (23)									
$\frac{\text{NPCOST}}{\text{PCOST}}$	0.645	0.540	467	0.692	0.546	174	0.617	0.529	290
γ_R	1.248	1.267	464	0.994	1.016	174	1.400	1.358	290
$\gamma_{y,R}$	1.043	1.064	463	0.855	0.877	172	1.157	1.142	290
α	1.265	1.167	385	0.932	0.754	135	1.444	1.274	250

Notes: In Panel B, I use GMM with the demand side instruments to estimate cost structure. (See Appendix B for the details.) See Table TA2 for the results for each six-digit NAICS industry.

Table A3: Unweighted Summary Statistics: Volatility

		Total			SEOS			LEOS		
		output	export	import	output	export	import	output	export	import
					Panel A: HP-filtered series					
Nondurable	mean	6.267	1.982	1.903	5.696	2.217	2.222	7.404	1.525	1.284
	median	5.846	1.386	1.204	5.417	1.552	1.414	7.049	1.163	1.031
Durable	mean	7.779	1.613	1.768	7.035	1.736	2.013	8.285	1.529	1.597
	median	7.188	1.269	1.468	6.807	1.337	1.539	7.727	1.223	1.419
Total	mean	7.151	1.759	1.821	6.345	1.978	2.118	8.019	1.528	1.513
	median	6.697	1.320	1.395	6.092	1.403	1.487	7.449	1.222	1.258
					Panel B: Growth rate					
Nondurable	mean	10.486	2.070	1.866	9.389	2.328	2.200	12.644	1.566	1.210
	median	9.651	1.452	1.241	8.825	1.550	1.415	11.963	1.244	1.021
Durable	mean	12.307	1.681	1.804	11.247	1.804	2.011	13.029	1.599	1.660
	median	11.189	1.336	1.449	10.632	1.401	1.565	11.823	1.263	1.414
Total	mean	11.551	1.835	1.828	10.290	2.067	2.106	12.913	1.590	1.539
	median	10.674	1.384	1.380	9.755	1.496	1.501	11.849	1.260	1.289

Notes: The numbers of industries are equal to the numbers in Table 3. Volatilities of output are measured by standard deviations in terms of percentage. Volatilities of imports and exports are measured by standard deviations relative to output.

Table A4: Unweighted Summary Statistics: Cylicality

		Total			SEOS			LEOS		
		output	export	import	output	export	import	output	export	import
					Panel A: HP-filtered series					
Nondurable	mean	0.351	0.241	0.429	0.333	0.218	0.389	0.389	0.276	0.509
	median	0.360	0.244	0.495	0.352	0.244	0.474	0.421	0.242	0.528
Durable	mean	0.533	0.410	0.552	0.470	0.340	0.504	0.576	0.462	0.586
	median	0.574	0.465	0.622	0.505	0.401	0.574	0.641	0.534	0.667
Total	mean	0.457	0.343	0.503	0.400	0.279	0.447	0.520	0.412	0.565
	median	0.505	0.386	0.573	0.438	0.326	0.518	0.570	0.456	0.625
					Panel B: Growth rate					
Nondurable	mean	0.365	0.244	0.432	0.345	0.226	0.393	0.407	0.270	0.514
	median	0.358	0.265	0.473	0.357	0.260	0.448	0.381	0.284	0.550
Durable	mean	0.512	0.372	0.523	0.452	0.308	0.473	0.554	0.420	0.559
	median	0.549	0.396	0.595	0.475	0.328	0.537	0.594	0.469	0.619
Total	mean	0.451	0.322	0.487	0.397	0.267	0.433	0.509	0.380	0.547
	median	0.487	0.342	0.555	0.419	0.278	0.499	0.550	0.403	0.607

Notes: The numbers of industries are equal to the numbers in Table 4. Cyclicalities are correlations to the aggregated business cycle component of outputs that is the average of individual industry's business cycle component of the real value of shipments, which is weighted by using the unfiltered real output share in each year.

Table A5: Regression Results: Alternative Cyclicality of Output and Market Structures

	Correlation to the Business Cycle Component of GDP							
	HP-filtered Series				Growth rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	0.214***	0.211***	0.266***	0.269***	0.228***	0.233***	0.295***	0.287***
	(0.055)	(0.056)	(0.069)	(0.069)	(0.050)	(0.052)	(0.063)	(0.063)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			-0.002	-0.007			-0.010	0.019
			(0.110)	(0.113)			(0.100)	(0.103)
b_2 : EOS_{NC}	-0.438***	-0.351***	0.110	0.160	-0.380***	-0.319***	0.175*	0.173*
	(0.053)	(0.060)	(0.102)	(0.106)	(0.049)	(0.055)	(0.092)	(0.096)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			-0.625***	-0.715***			-0.668***	-0.664***
			(0.113)	(0.127)			(0.103)	(0.115)
b_3 : $\ln \varepsilon$	-0.028	-0.028	-0.037*	-0.074**	-0.032	-0.033*	-0.042**	-0.073***
	(0.022)	(0.022)	(0.021)	(0.030)	(0.020)	(0.020)	(0.019)	(0.028)
$b_{3,D}$: $D \times \ln \varepsilon$				0.075*				0.056
				(0.042)				(0.038)
b_4 : $\ln \theta_m$		0.197***	0.213***	0.265***		0.137**	0.154***	0.107
		(0.065)	(0.063)	(0.091)		(0.060)	(0.057)	(0.082)
$b_{3,D}$: $D \times \ln \varepsilon$				-0.126				0.072
				(0.126)				(0.115)
b_5 : Constant	0.668***	0.715***	0.482***	0.482***	0.600***	0.641***	0.391***	0.349***
	(0.033)	(0.047)	(0.063)	(0.072)	(0.030)	(0.043)	(0.057)	(0.065)
$b_{5,D}$: D		0.074***	0.393***	0.378***		0.036	0.377***	0.442***
		(0.028)	(0.065)	(0.089)		(0.026)	(0.059)	(0.080)
Observations	351	351	351	351	351	351	351	351
R^2	0.194	0.233	0.294	0.303	0.196	0.214	0.299	0.304

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The real GDP data are from the Penn World Table 9.0.

Table A6: Regression Results: Alternative Cyclicality of Export and Market Structures

		Correlation to the Business Cycle Component of GDP							
		HP-filtered Series				Growth rates			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1	: EOS_{MC}	0.362***	0.363***	0.338***	0.341***	0.341***	0.333***	0.302***	0.296***
		(0.064)	(0.067)	(0.086)	(0.087)	(0.054)	(0.057)	(0.072)	(0.072)
$b_{1,D}$	: $D \times \text{EOS}_{MC}$			0.088	0.080			0.112	0.134
				(0.137)	(0.142)			(0.115)	(0.118)
b_2	: EOS_{NC}	-0.163***	-0.101	-0.037	-0.021	0.041	0.032	0.128	0.120
		(0.063)	(0.071)	(0.126)	(0.133)	(0.052)	(0.060)	(0.106)	(0.111)
$b_{2,D}$	: $D \times \text{EOS}_{NC}$			-0.097	-0.125			-0.143	-0.128
				(0.141)	(0.159)			(0.118)	(0.133)
b_3	: $\ln \varepsilon$	-0.067***	-0.068***	-0.068***	-0.074*	-0.067***	-0.066***	-0.066***	-0.083***
		(0.026)	(0.026)	(0.026)	(0.038)	(0.022)	(0.022)	(0.022)	(0.032)
$b_{3,D}$	: $D \times \ln \varepsilon$				0.012				0.029
					(0.052)				(0.044)
b_4	: $\ln \theta_m$		0.141*	0.148*	0.174		-0.020	-0.010	-0.050
			(0.078)	(0.079)	(0.113)		(0.066)	(0.066)	(0.095)
$b_{3,D}$	: $D \times \ln \varepsilon$				-0.053				0.068
					(0.158)				(0.132)
b_5	: Constant	0.331***	0.370***	0.343***	0.351***	0.151***	0.136***	0.094	0.065
		(0.039)	(0.056)	(0.078)	(0.090)	(0.032)	(0.047)	(0.065)	(0.075)
$b_{5,D}$	: D		0.044	0.083	0.066		0.011	0.071	0.119
			(0.033)	(0.080)	(0.111)		(0.028)	(0.067)	(0.093)
Observations		351	351	351	351	351	351	351	351
R^2		0.123	0.136	0.138	0.139	0.140	0.141	0.146	0.148

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The real GDP data are from the Penn World Table 9.0.

Table A7: Regression Results: Alternative Cyclicality of Import and Market Structures

	Correlation to the Business Cycle Component of GDP							
	HP-filtered Series				Growth rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
b_1 : EOS_{MC}	0.212***	0.247***	0.263***	0.291***	0.119**	0.138**	0.175**	0.175**
	(0.061)	(0.062)	(0.078)	(0.077)	(0.053)	(0.055)	(0.070)	(0.070)
$b_{1,D}$: $D \times \text{EOS}_{MC}$			0.009	-0.079			-0.017	-0.012
			(0.125)	(0.126)			(0.111)	(0.114)
b_2 : EOS_{NC}	-0.343***	-0.173***	-0.015	0.136	-0.159***	-0.073	0.185*	0.233**
	(0.060)	(0.065)	(0.115)	(0.118)	(0.052)	(0.059)	(0.103)	(0.107)
$b_{2,D}$: $D \times \text{EOS}_{NC}$			-0.216*	-0.491***			-0.347***	-0.433***
			(0.129)	(0.142)			(0.114)	(0.128)
b_3 : $\ln \varepsilon$	0.000	-0.005	-0.008	-0.043	-0.012	-0.015	-0.020	-0.066**
	(0.025)	(0.024)	(0.024)	(0.034)	(0.021)	(0.021)	(0.021)	(0.031)
$b_{3,D}$: $D \times \ln \varepsilon$				0.086*				0.091**
				(0.046)				(0.042)
b_4 : $\ln \theta_m$		0.385***	0.391***	0.658***		0.196***	0.204***	0.238***
		(0.071)	(0.072)	(0.101)		(0.064)	(0.064)	(0.091)
$b_{3,D}$: $D \times \ln \varepsilon$				-0.546***				-0.097
				(0.141)				(0.127)
b_5 : Constant	0.669***	0.809***	0.730***	0.831***	0.560***	0.633***	0.502***	0.487***
	(0.037)	(0.051)	(0.071)	(0.080)	(0.032)	(0.046)	(0.063)	(0.072)
$b_{5,D}$: D		0.056*	0.164**	-0.034		0.025	0.204***	0.212**
		(0.031)	(0.073)	(0.099)		(0.027)	(0.065)	(0.089)
Observations	351	351	351	351	351	351	351	351
R^2	0.108	0.188	0.195	0.234	0.040	0.069	0.093	0.106

Notes: Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All results are weighted by using the over-time average output share of industry defined in Equation (25). The real GDP data are from the Penn World Table 9.0.

F Technical Appendix

F.1 Steady State Export Cutoff

In the steady state, all factor prices are identical across industries because the adjustment cost structures imply fully flexible cross-industry reallocations of factors in the long run. For convenience, Define Υ_N^s and Υ_X^s as follows.

$$\Upsilon_N^s = \left(\frac{ED_X^s}{ED_N^s}\right)^{(\alpha^s-1)\zeta^s+1} - 1$$
$$\Upsilon_X^s = \left(\frac{ED_X^s}{ED_N^s}\right)^{-(\alpha^s-1)\zeta^s} \Upsilon_N^s = \left(\frac{ED_X^s}{ED_N^s}\right) - \left(\frac{ED_X^s}{ED_N^s}\right)^{-(\alpha^s-1)\zeta^s}$$

$eg^s = \Upsilon_N^s/\Upsilon_X^s$ is the ratio of non-exporter's marginal costs to exporter's marginal costs, which represents the steady state efficiency export gains. $\alpha^s > 1$ causes the gains, so $eg^s = \Upsilon_N^s/\Upsilon_X^s > 1$. Without economies of scale - $\alpha^s = 1$ -, $eg^s = \Upsilon_N^s/\Upsilon_X^s = 1$ In the symmetric country case, $\Upsilon_N^s = \Upsilon_N^{s*} = \left(1+\tau^{1-\theta}\right)^{(\alpha^s-1)\zeta^s+1} - 1$ that is increasing in α^s.

The export cutoff can be rewritten by

$$\pi_X^s\left(z_X^s\right) + \frac{f_X^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}} + \pi_{D,X}^s\left(z_X^s\right) - \pi_{D,N}^s\left(z_X^s\right) = \frac{f_X^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}}$$
$$\tilde{\pi}_X^s + \tilde{\pi}_{D,X}^s - \pi_{D,N}^s\left(\tilde{z}_X^s\right) = \left[\left(\nu^s\right)^{\zeta^s} - 1\right] \frac{f_X^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}} \tag{TA1}$$

where $\nu^s = \left[k^s / \left(k^s - \zeta^s\right)\right]^{1/\zeta^s}$ $\tilde{z}_X^s = \nu^s z_X^s$ and $\tilde{z}_N^s = \nu^s z_N^s$. The profit functions yield

$$\pi_{D,N}^s\left(\tilde{z}_X^s\right) = \frac{\left(\nu^s\right)^{\zeta^s}}{\Upsilon_N^s} \frac{f_X^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}}. \tag{TA2}$$

Equivalently, I obtain that

$$\pi_{D,X}^s\left(\tilde{z}_X^s\right) = \tilde{\pi}_{D,X}^s = \frac{\left(\nu^s\right)^{\zeta^s}}{\Upsilon_X^s} \frac{f_X^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}}, \tag{TA3}$$

because I define Υ_N^s and Υ_X^s subject to $eg^s = \pi_{D,X}^s\left(\cdot\right)/\pi_{D,N}^s\left(\cdot\right) = \Upsilon_N^s/\Upsilon_X^s$.

The free entry condition implies that

$$\left[1 - \left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{k^s}\right] \tilde{\pi}_{D,N}^s + \left(\nu^s/\tilde{z}_X^s\right)^{k^s} \left(\tilde{\pi}_{D,X}^s + \tilde{\pi}_X^s\right) = \left[\frac{1}{\beta\left(1-\delta\right)} - 1\right] \frac{f_E^s w}{\alpha^s \left(Z^s\right)^{\frac{1}{\alpha^s}}}. \tag{TA4}$$

where $\tilde{\pi}_{D,N}^s = \pi_{D,N}^s\left(\tilde{z}_N^s\right)$. By using Equation (TA2) and $\tilde{z}_N^s = \tilde{z}_X^s \left\{\left[1 - \left(\tilde{z}_X^s/\nu^s\right)^{k^s-\zeta^s}\right] / \left[1 - \left(\tilde{z}_X^s/\nu^s\right)^{k^s}\right]\right\}^{1/\zeta^s}$, I obtain that

$$\left[\frac{1}{\beta(1-\delta)}-1\right]\frac{f_E^s w}{\alpha^s (Z^s)^{\frac{1}{\alpha^s}}}=\left[1-\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{k^s}\right]\tilde{\pi}_{D,N}^s+\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{k^s}\left\{\pi_{D,N}^s\left(\tilde{z}_X^s\right)+\left[(\nu^s)^{\zeta^s}-1\right]\frac{f_X^s w}{\alpha^s (Z^s)^{\frac{1}{\alpha^s}}}\right\}$$
$$=\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{\zeta^s}\pi_{D,N}\left(\tilde{z}_X\right)+\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{k^s}\left[(\nu^s)^{\zeta^s}-1\right]\frac{f_X^s w}{\alpha^s (Z^s)^{\frac{1}{\alpha^s}}}. \quad \text{(TA5)}$$

Finally, I obtain the following equation that only depends on the export cutoff - $\tilde{z}_X^s$ -, exogenous variables, and parameters.

$$\left[\frac{1}{\beta(1-\delta)}-1\right]\frac{f_E^s}{f_X^s}=\frac{(\nu^s)^{\zeta^s}}{\Upsilon_N^s}\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{\zeta^s}+\left[(\nu^s)^{\zeta^s}-1\right]\left(\frac{\nu^s}{\tilde{z}_X^s}\right)^{k^s} \quad \text{(TA6)}$$

The symmetric country case, $\rho^s = Q\rho^{s*}$ and $QD^* = D$. $\Upsilon_N^s = \left(1+\tau^{1-\theta}\right)^{(\alpha^s-1)\zeta^s+1} - 1$ is constant. Thus, the above equation is the unique implicit steady state solution to the cutoff. Equation (TA6) can be rewritten by

$$\left[\frac{1}{\beta(1-\delta)}-1\right]\frac{f_E^s}{f_X^s}=\frac{(\nu^s)^{\zeta^s}}{\Upsilon_N^s}\left(\frac{N_X^s}{N^s}\right)^{\frac{\zeta^s}{k^s}}+\left[(\nu^s)^{\zeta^s}-1\right]\left(\frac{N_X^s}{N^s}\right). \quad \text{(TA7)}$$

Interestingly, the fraction of exporter does not depend on the other industry's characteristics in the steady state.

F.2 Tables

Table TA1: Industry Groups

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
311 Food Manufacturing					non-durable
311111	SEOS	SEOS	SEOS	SEOS	
311119		SEOS	SEOS	SEOS	
311211	SEOS	SEOS	SEOS	SEOS	
311212	SEOS	SEOS	SEOS	SEOS	
311213	SEOS	SEOS		SEOS	
311221	SEOS	SEOS			
311222	SEOS	SEOS		SEOS	
311223	SEOS	SEOS	LEOS	LEOS	
311225	SEOS	SEOS	SEOS	SEOS	
311230	SEOS	SEOS	SEOS	SEOS	
311311	SEOS	SEOS	SEOS	SEOS	

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
311312	SEOS	SEOS	SEOS	SEOS	
311313	SEOS	SEOS	SEOS	SEOS	
311320	SEOS	SEOS	SEOS	SEOS	
311330	SEOS	SEOS	SEOS	SEOS	
311340	SEOS	SEOS	SEOS	SEOS	
311411	SEOS	SEOS	SEOS	SEOS	
311412	SEOS	SEOS	SEOS	LEOS	
311421	SEOS	SEOS	SEOS	SEOS	
311422	SEOS	SEOS	LEOS	LEOS	
311423	LEOS	SEOS	LEOS	LEOS	
311511	SEOS	SEOS	SEOS	SEOS	
311512	SEOS	SEOS		SEOS	
311513	SEOS	SEOS		SEOS	
311514	SEOS	SEOS		SEOS	
311520	SEOS	SEOS	SEOS	SEOS	
311611	SEOS	SEOS		SEOS	
311612	SEOS	SEOS	SEOS	SEOS	
311613	SEOS	SEOS	SEOS	SEOS	
311615	SEOS	SEOS	SEOS	SEOS	
311711	SEOS	SEOS	SEOS	SEOS	
311712	SEOS	SEOS	SEOS	SEOS	
311812	SEOS	SEOS	SEOS	SEOS	
311813	LEOS	LEOS	LEOS	LEOS	
311821		SEOS	SEOS	SEOS	
311822	SEOS	SEOS	SEOS	SEOS	
311823	SEOS	SEOS	SEOS	LEOS	
311830	LEOS	LEOS	SEOS	LEOS	
311911	SEOS	SEOS	SEOS	LEOS	
311919	SEOS	SEOS	SEOS	SEOS	
311920					
311930	SEOS	SEOS	SEOS	SEOS	
311941	LEOS	LEOS	LEOS	LEOS	
311942	LEOS	LEOS	LEOS	LEOS	
311991	LEOS	LEOS	LEOS	LEOS	
311999	LEOS	LEOS	LEOS	LEOS	
312 Beverage and Tobacco Product Manufacturing					non-durable
312111	SEOS	SEOS	SEOS	SEOS	
312112	SEOS	SEOS	SEOS	SEOS	
312113	SEOS	SEOS	SEOS	SEOS	

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
312120	SEOS	SEOS			
312130	SEOS	SEOS		SEOS	
312140	SEOS	SEOS	SEOS	SEOS	
312210	SEOS	SEOS	SEOS	SEOS	
312221	SEOS	SEOS	SEOS	SEOS	
312229	SEOS	SEOS	SEOS	SEOS	
313 Textile Mills					non-durable
313111	SEOS	SEOS	SEOS	SEOS	
313112	SEOS	SEOS	SEOS	SEOS	
313113	LEOS	LEOS	LEOS	LEOS	
313210	SEOS	SEOS	LEOS	LEOS	
313221	SEOS	SEOS	SEOS	SEOS	
313222	LEOS	LEOS	LEOS	LEOS	
313230	SEOS	SEOS	SEOS	SEOS	
313241	LEOS	LEOS	SEOS	LEOS	
313249	LEOS	LEOS	LEOS	LEOS	
313311	SEOS	SEOS	SEOS	SEOS	
313312	LEOS	LEOS	SEOS	SEOS	
313320	LEOS	LEOS	LEOS	LEOS	
314 Textile Product Mills					non-durable
314110	SEOS	SEOS	LEOS	LEOS	
314121	LEOS	LEOS	SEOS	LEOS	
314129	LEOS	LEOS	SEOS	LEOS	
314911	SEOS	SEOS	SEOS	SEOS	
314912	LEOS	LEOS	SEOS	SEOS	
314991	SEOS	SEOS	SEOS	LEOS	
314992	SEOS	SEOS	SEOS	SEOS	
314999	LEOS	LEOS	LEOS	LEOS	
315 Apparel Manufacturing					non-durable
315111	LEOS	LEOS	SEOS	SEOS	
315119	LEOS	LEOS	SEOS	SEOS	
315191	LEOS	LEOS	SEOS	LEOS	
315192	LEOS	LEOS	LEOS	LEOS	
315221	LEOS	LEOS	LEOS	LEOS	
315222	LEOS	LEOS	SEOS	SEOS	
315223	LEOS	LEOS	LEOS	LEOS	
315224	LEOS	LEOS	LEOS	LEOS	
315225	LEOS	LEOS	SEOS	SEOS	
315228	LEOS	LEOS	SEOS	SEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
315231	LEOS	LEOS	LEOS	LEOS	
315232	SEOS	SEOS	SEOS	LEOS	
315233	LEOS	LEOS	SEOS	LEOS	
315234	SEOS	LEOS	LEOS	LEOS	
315239	LEOS	LEOS	LEOS	LEOS	
315291	LEOS	LEOS	LEOS	LEOS	
315292	SEOS	SEOS	SEOS	SEOS	
315299	LEOS	SEOS	LEOS	LEOS	
315991	SEOS	SEOS	SEOS	SEOS	
315992	SEOS	SEOS	SEOS	SEOS	
315993	SEOS	SEOS	SEOS	SEOS	
315999	LEOS	LEOS	LEOS	LEOS	
316 Leather and Allied Product Manufacturing					non-durable
316110	SEOS	SEOS	SEOS	SEOS	
316211	SEOS	SEOS	SEOS	SEOS	
316212	LEOS	LEOS	SEOS	LEOS	
316213	LEOS	LEOS	SEOS	SEOS	
316214	LEOS	LEOS	SEOS	SEOS	
316219	LEOS	LEOS	SEOS	LEOS	
316991	SEOS	SEOS	SEOS	SEOS	
316992	LEOS	LEOS	LEOS	LEOS	
316993	SEOS	SEOS	SEOS	SEOS	
316999	LEOS	LEOS	SEOS	SEOS	
321 Wood Product Manufacturing					durable
321113	SEOS	SEOS	SEOS	SEOS	
321114	SEOS	SEOS	SEOS	SEOS	
321211	SEOS	SEOS	SEOS	LEOS	
321212	SEOS	LEOS	SEOS	SEOS	
321213	LEOS	LEOS	LEOS	LEOS	
321214	LEOS	LEOS	SEOS	SEOS	
321219	SEOS	SEOS	SEOS	SEOS	
321911	LEOS	LEOS	SEOS	LEOS	
321912	SEOS	SEOS	SEOS	LEOS	
321918	LEOS	LEOS	LEOS	LEOS	
321920	SEOS	SEOS	SEOS	SEOS	
321991	LEOS	LEOS	LEOS	LEOS	
321992	LEOS	LEOS	LEOS	LEOS	
321999	SEOS	SEOS	SEOS	SEOS	
322 Paper Manufacturing					non-durable

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
322110	SEOS	SEOS	SEOS	SEOS	
322121		SEOS	LEOS	LEOS	
322122	SEOS	SEOS	SEOS	SEOS	
322130	SEOS	SEOS	SEOS	LEOS	
322211	SEOS	SEOS	SEOS	SEOS	
322212	SEOS	SEOS	SEOS	LEOS	
322213	SEOS	SEOS	SEOS	SEOS	
322214	LEOS	LEOS	LEOS	LEOS	
322215	SEOS	SEOS	SEOS	LEOS	
322221	SEOS	SEOS	SEOS	LEOS	
322222	LEOS	LEOS	LEOS	LEOS	
322223	SEOS	SEOS	LEOS	LEOS	
322224	SEOS	SEOS	SEOS	SEOS	
322225	LEOS	LEOS	LEOS	LEOS	
322226	SEOS	SEOS	LEOS	LEOS	
322231	LEOS	LEOS	LEOS	LEOS	
322232	LEOS	LEOS	LEOS	LEOS	
322233	SEOS	SEOS	SEOS	SEOS	
322291	LEOS	LEOS	LEOS	LEOS	
322299	LEOS	LEOS	LEOS	LEOS	
323 Printing and Related Support Activities					non-durable
323110	LEOS	LEOS	SEOS	LEOS	
323111	LEOS	LEOS	SEOS	LEOS	
323112	LEOS	LEOS	LEOS	LEOS	
323113	SEOS	SEOS	SEOS	SEOS	
323114	SEOS	SEOS	SEOS	LEOS	
323115	LEOS	LEOS	LEOS	LEOS	
323116	LEOS	LEOS	LEOS	LEOS	
323117	SEOS	SEOS	SEOS	SEOS	
323118	LEOS	LEOS	SEOS	SEOS	
323119	SEOS	SEOS	SEOS	LEOS	
323121	SEOS	SEOS	SEOS	SEOS	
323122	SEOS	SEOS	LEOS	LEOS	
324 Petroleum and Coal Products Manufacturing					non-durable
324110	SEOS	SEOS	SEOS	SEOS	
324121	SEOS	SEOS	LEOS	LEOS	
324122		SEOS	LEOS	LEOS	
324191	SEOS	SEOS	LEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
324199	SEOS	SEOS	SEOS	SEOS	
325 Chemical Manufacturing					non-durable
325110	SEOS	SEOS	SEOS	LEOS	
325120	LEOS	LEOS	LEOS	LEOS	
325131	SEOS	SEOS	SEOS	SEOS	
325132	SEOS	SEOS	SEOS	SEOS	
325181	LEOS	LEOS	SEOS	SEOS	
325182	SEOS	SEOS	LEOS	LEOS	
325188	LEOS	LEOS	LEOS	LEOS	
325191	SEOS	SEOS	SEOS	SEOS	
325192	SEOS	SEOS	SEOS	LEOS	
325193	SEOS	SEOS	SEOS	SEOS	
325199	SEOS	SEOS	SEOS	LEOS	
325211	SEOS	SEOS	SEOS	LEOS	
325212	SEOS	SEOS	SEOS	SEOS	
325221	LEOS	SEOS	SEOS	SEOS	
325222	SEOS	SEOS	LEOS	LEOS	
325311	SEOS	SEOS	SEOS	SEOS	
325312	SEOS	SEOS	LEOS	LEOS	
325314	SEOS	SEOS	LEOS	LEOS	
325320	SEOS	SEOS	SEOS	SEOS	
325411	LEOS	LEOS	LEOS	LEOS	
325412	SEOS	SEOS	LEOS	LEOS	
325413	LEOS	LEOS	SEOS	SEOS	
325414	SEOS	LEOS	SEOS	SEOS	
325510	SEOS	SEOS	SEOS	LEOS	
325520	SEOS	SEOS	LEOS	LEOS	
325611	SEOS	SEOS	SEOS	SEOS	
325612	SEOS	SEOS	SEOS	SEOS	
325613	SEOS	SEOS	LEOS	LEOS	
325620	SEOS	SEOS	SEOS	SEOS	
325910	SEOS	SEOS	LEOS	LEOS	
325920	LEOS	LEOS	LEOS	LEOS	
325991	SEOS	LEOS	LEOS	LEOS	
325992	SEOS	SEOS	SEOS	SEOS	
325998	SEOS	SEOS	LEOS	LEOS	
326 Plastics and Rubber Products Manufacturing					non-durable
326111	SEOS	SEOS	SEOS	SEOS	
326112	SEOS	SEOS	SEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
326113	LEOS	LEOS		LEOS	
326121	LEOS	LEOS	LEOS	LEOS	
326122	SEOS	SEOS	LEOS	LEOS	
326130	LEOS	LEOS	SEOS	LEOS	
326140	SEOS	SEOS	LEOS	LEOS	
326150	LEOS	LEOS	LEOS	LEOS	
326160	SEOS	SEOS	LEOS	LEOS	
326191	LEOS	LEOS	LEOS	LEOS	
326192	LEOS	LEOS	LEOS	LEOS	
326199	LEOS	LEOS		LEOS	
326211	SEOS	SEOS	LEOS	LEOS	
326220	LEOS	LEOS	LEOS	LEOS	
326291	LEOS	LEOS	SEOS	LEOS	
326299	LEOS	LEOS	LEOS	LEOS	
327 Nonmetallic Mineral Product Manufacturing					durable
327111		LEOS	LEOS	LEOS	
327112	LEOS	SEOS	SEOS	SEOS	
327113	LEOS	LEOS	LEOS	LEOS	
327121	LEOS	LEOS	SEOS	LEOS	
327122	SEOS	SEOS	SEOS	SEOS	
327123	SEOS	SEOS	SEOS	SEOS	
327124	LEOS	LEOS	LEOS	LEOS	
327125	LEOS	LEOS	LEOS	LEOS	
327211	SEOS	LEOS	SEOS	LEOS	
327212	SEOS	SEOS	LEOS	LEOS	
327213	SEOS	SEOS	SEOS	SEOS	
327215	SEOS	LEOS	LEOS	LEOS	
327310	SEOS	LEOS	SEOS	LEOS	
327320	LEOS	LEOS	LEOS	LEOS	
327331	LEOS	LEOS	SEOS	SEOS	
327332	LEOS	LEOS	LEOS	LEOS	
327390	LEOS	LEOS	LEOS	LEOS	
327410	SEOS	SEOS	LEOS	LEOS	
327420	LEOS	LEOS	SEOS	LEOS	
327910	LEOS	LEOS	LEOS	LEOS	
327991	LEOS	LEOS	LEOS	LEOS	
327992	SEOS	SEOS	SEOS	SEOS	
327993	LEOS	LEOS	LEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
327999	SEOS	SEOS	SEOS	SEOS	
331 Primary Metal Manufacturing					durable
331111	SEOS	LEOS	SEOS	LEOS	
331112	SEOS	SEOS	SEOS	LEOS	
331210	LEOS	LEOS	LEOS	LEOS	
331221	LEOS	LEOS	LEOS	LEOS	
331222	LEOS	LEOS		LEOS	
331311	SEOS	SEOS	SEOS	SEOS	
331312	SEOS	SEOS	SEOS	LEOS	
331314	SEOS	SEOS	SEOS	SEOS	
331315	SEOS	SEOS	LEOS	LEOS	
331316	SEOS	SEOS	LEOS	LEOS	
331319	LEOS	LEOS	LEOS	LEOS	
331411	SEOS	SEOS	SEOS	SEOS	
331419	SEOS	SEOS	SEOS	SEOS	
331421	SEOS	SEOS	LEOS	LEOS	
331422	SEOS	SEOS	SEOS	SEOS	
331423	SEOS	SEOS	SEOS	SEOS	
331491	SEOS	SEOS	SEOS	LEOS	
331492	SEOS	SEOS	SEOS	SEOS	
331511	LEOS	LEOS	SEOS	LEOS	
331512	LEOS	LEOS	SEOS	LEOS	
331513	LEOS	LEOS	SEOS	LEOS	
331521	SEOS	LEOS	LEOS	LEOS	
331522	LEOS	LEOS	LEOS	LEOS	
331524	LEOS	LEOS	LEOS	LEOS	
331525	SEOS	SEOS	SEOS	SEOS	
331528	SEOS	SEOS	SEOS	SEOS	
332 Fabricated Metal Product Manufacturing					durable
332111	LEOS	LEOS	LEOS	LEOS	
332112	SEOS	SEOS	SEOS	SEOS	
332114	SEOS	SEOS	LEOS	LEOS	
332115	LEOS	LEOS	LEOS	LEOS	
332116	LEOS	LEOS	LEOS	LEOS	
332117	LEOS	SEOS	SEOS	SEOS	
332211	SEOS	SEOS	LEOS	LEOS	
332212	LEOS	LEOS	LEOS	LEOS	
332213	SEOS	SEOS	LEOS	LEOS	
332214	SEOS	LEOS	SEOS	SEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
332311	SEOS	SEOS	LEOS	LEOS	
332312	SEOS	SEOS	SEOS	SEOS	
332313	LEOS	SEOS	SEOS	SEOS	
332321	LEOS	LEOS	LEOS	LEOS	
332322	LEOS	LEOS	LEOS	LEOS	
332323	SEOS	LEOS	LEOS	LEOS	
332410	SEOS	LEOS	SEOS	SEOS	
332420	LEOS	LEOS	SEOS	SEOS	
332431	SEOS	SEOS		SEOS	
332439	SEOS	SEOS	LEOS	LEOS	
332510	LEOS	LEOS	LEOS	LEOS	
332611	LEOS	LEOS	LEOS	LEOS	
332612	LEOS	LEOS	LEOS	LEOS	
332618	LEOS	LEOS	LEOS	LEOS	
332710	SEOS	LEOS	SEOS	LEOS	
332721	LEOS	LEOS	LEOS	LEOS	
332722	LEOS	LEOS	LEOS	LEOS	
332811	SEOS	LEOS	LEOS	LEOS	
332812	SEOS	SEOS	SEOS	SEOS	
332813	LEOS	LEOS	LEOS	LEOS	
332911	LEOS	LEOS	SEOS	LEOS	
332912	LEOS	LEOS	LEOS	LEOS	
332913	LEOS	LEOS	LEOS	LEOS	
332919	LEOS	LEOS	LEOS	LEOS	
332991	LEOS	LEOS	SEOS	LEOS	
332992	SEOS	SEOS	SEOS	SEOS	
332993	LEOS	LEOS	SEOS	SEOS	
332994	SEOS	LEOS	SEOS	SEOS	
332995	SEOS	SEOS	SEOS	SEOS	
332996	LEOS	SEOS	SEOS	LEOS	
332997	LEOS	LEOS	LEOS	LEOS	
332998	LEOS	LEOS	LEOS	LEOS	
332999	SEOS	SEOS	SEOS	LEOS	
333 - Machinery manufacturing					durable
333111	LEOS	LEOS	SEOS	SEOS	
333112	LEOS	LEOS	LEOS	LEOS	
333120	SEOS	LEOS	SEOS	LEOS	
333131	LEOS	LEOS	SEOS	LEOS	
333132	LEOS	LEOS	LEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
333210	LEOS	LEOS	LEOS	LEOS	
333220	LEOS	LEOS	LEOS	LEOS	
333291	SEOS	SEOS	SEOS	SEOS	
333292	LEOS	LEOS	LEOS	LEOS	
333293	LEOS	LEOS	SEOS	LEOS	
333294	LEOS	LEOS	LEOS	LEOS	
333295	LEOS	LEOS	SEOS	SEOS	
333298	LEOS	LEOS	LEOS	LEOS	
333311	LEOS	LEOS	LEOS	LEOS	
333312	SEOS	SEOS	SEOS	SEOS	
333313	SEOS	SEOS	LEOS	LEOS	
333314	LEOS	LEOS	SEOS	LEOS	
333315	SEOS	SEOS	SEOS	LEOS	
333319	LEOS	LEOS	LEOS	LEOS	
333411	SEOS	SEOS	LEOS	LEOS	
333412	SEOS	SEOS	SEOS	LEOS	
333414	LEOS	LEOS	SEOS	LEOS	
333415	LEOS	LEOS	LEOS	LEOS	
333511	LEOS	LEOS		LEOS	
333512	LEOS	LEOS	SEOS	LEOS	
333513	LEOS	LEOS	LEOS	LEOS	
333514	LEOS	LEOS	SEOS	LEOS	
333515	LEOS	LEOS	LEOS	LEOS	
333516	LEOS	LEOS	SEOS	SEOS	
333518	LEOS	LEOS	SEOS	SEOS	
333611	SEOS	SEOS	SEOS	SEOS	
333612	LEOS	LEOS	SEOS	LEOS	
333613	LEOS	LEOS	LEOS	LEOS	
333618	LEOS	LEOS	LEOS	LEOS	
333911	LEOS	LEOS	SEOS	SEOS	
333912	SEOS	SEOS	LEOS	LEOS	
333913	SEOS	SEOS	LEOS	LEOS	
333921	SEOS	SEOS	SEOS	LEOS	
333922	LEOS	LEOS	LEOS	LEOS	
333923	LEOS	LEOS	LEOS	LEOS	
333924	LEOS	LEOS	LEOS	LEOS	
333991	LEOS	LEOS	SEOS	LEOS	
333992	SEOS	SEOS	SEOS	LEOS	
333993	LEOS	LEOS	SEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
333994	LEOS	LEOS	SEOS	LEOS	
333995	SEOS	SEOS	LEOS	LEOS	
333996	LEOS	LEOS	LEOS	LEOS	
333997	SEOS	LEOS	LEOS	LEOS	
333999	SEOS	SEOS	SEOS	SEOS	
334 Computer and Electronic Product Manufacturing					durable
334111	LEOS	LEOS	SEOS	SEOS	
334112	SEOS	SEOS	LEOS	LEOS	
334113	LEOS	LEOS	LEOS	LEOS	
334119	SEOS	SEOS	SEOS	SEOS	
334210	LEOS	LEOS	LEOS	LEOS	
334220	SEOS	SEOS	SEOS	SEOS	
334290	LEOS	LEOS	SEOS	SEOS	
334310	SEOS	SEOS	SEOS	SEOS	
334411	SEOS	LEOS	LEOS	LEOS	
334412	LEOS	LEOS	SEOS	SEOS	
334413	LEOS	LEOS	SEOS	LEOS	
334414	LEOS	LEOS	SEOS	SEOS	
334415	LEOS	LEOS	LEOS	LEOS	
334416	LEOS	LEOS	LEOS	LEOS	
334417	LEOS	SEOS	LEOS	LEOS	
334418	LEOS	LEOS	SEOS	SEOS	
334419	SEOS	SEOS		SEOS	
334510	SEOS	SEOS	SEOS	SEOS	
334511	SEOS	SEOS	SEOS	SEOS	
334512	LEOS	LEOS	LEOS	LEOS	
334513	SEOS	LEOS	SEOS	SEOS	
334514	SEOS	LEOS	LEOS	LEOS	
334515	LEOS	LEOS	LEOS	LEOS	
334516	LEOS	LEOS	SEOS	LEOS	
334517	SEOS	LEOS	SEOS	SEOS	
334518	LEOS	SEOS	SEOS	LEOS	
334519	SEOS	SEOS	SEOS	SEOS	
334612	SEOS	SEOS	SEOS	SEOS	
334613	SEOS	SEOS	SEOS	SEOS	
335 Electrical Equipment, Appliance, and Component Manufacturing					durable
335110	LEOS	LEOS	LEOS	LEOS	
335121	LEOS	SEOS	LEOS	LEOS	
335122	LEOS	LEOS	LEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
335129	LEOS	LEOS	LEOS	LEOS	
335211	SEOS	LEOS	SEOS	SEOS	
335212	LEOS	LEOS	LEOS	LEOS	
335221	SEOS	SEOS	SEOS	SEOS	
335222	SEOS	SEOS	SEOS	SEOS	
335224	LEOS	LEOS	LEOS	LEOS	
335228	SEOS	LEOS	SEOS	LEOS	
335311	LEOS	LEOS	LEOS	LEOS	
335312	LEOS	LEOS	LEOS	LEOS	
335313	LEOS	LEOS	LEOS	LEOS	
335314	LEOS	LEOS	LEOS	LEOS	
335911	SEOS	SEOS	SEOS	LEOS	
335912	SEOS	SEOS	SEOS	SEOS	
335921	SEOS	SEOS	SEOS	SEOS	
335929	SEOS	SEOS	SEOS	LEOS	
335931	LEOS	LEOS	LEOS	LEOS	
335932	LEOS	LEOS	LEOS	LEOS	
335991	SEOS	LEOS	LEOS	LEOS	
335999	LEOS	LEOS		LEOS	
336 Transportation Equipment Manufacturing					durable
336111	LEOS	LEOS	SEOS	LEOS	
336112	SEOS	LEOS	LEOS	LEOS	
336120	LEOS	LEOS	SEOS	LEOS	
336211	SEOS	LEOS	SEOS	LEOS	
336212	LEOS	LEOS	LEOS	LEOS	
336213	LEOS	LEOS	LEOS	LEOS	
336214	LEOS	LEOS	LEOS	LEOS	
336311	LEOS	LEOS	SEOS	LEOS	
336312	SEOS	LEOS	LEOS	LEOS	
336321	SEOS	LEOS	SEOS	LEOS	
336322	LEOS	LEOS	SEOS	LEOS	
336330	LEOS	LEOS	LEOS	LEOS	
336340	LEOS	LEOS	LEOS	LEOS	
336350	LEOS	LEOS	LEOS	LEOS	
336360	SEOS	SEOS	SEOS	SEOS	
336370	LEOS	LEOS		LEOS	
336391	LEOS	LEOS	LEOS	LEOS	
336399	LEOS	LEOS	LEOS	LEOS	
336411	SEOS	SEOS	SEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

6 Digit NAICS	Uninstrumented Benchmark	Uninstrumented Alternative	Uninstrumented Benchmark	Uninstrumented Alternative	Classification
336412	LEOS	LEOS	LEOS	LEOS	
336413	SEOS	SEOS	SEOS	SEOS	
336414	SEOS	SEOS	SEOS	SEOS	
336415	SEOS	LEOS	LEOS	LEOS	
336419	LEOS	LEOS	LEOS	LEOS	
336510	LEOS	LEOS	LEOS	LEOS	
336611	SEOS	SEOS	SEOS	SEOS	
336612	LEOS	LEOS	SEOS	LEOS	
336991	LEOS	LEOS	LEOS	LEOS	
336992	LEOS	LEOS		LEOS	
336999	SEOS	LEOS	LEOS	LEOS	
337 Furniture and Related Product Manufacturing					durable
337110	LEOS	LEOS	SEOS	LEOS	
337121	LEOS	LEOS	LEOS	LEOS	
337122	LEOS	LEOS	LEOS	LEOS	
337124	LEOS	LEOS	LEOS	LEOS	
337125	LEOS	LEOS	LEOS	SEOS	
337127	SEOS	SEOS	LEOS	LEOS	
337129	LEOS	SEOS	LEOS	LEOS	
337211	LEOS	LEOS	LEOS	LEOS	
337212	LEOS	LEOS	LEOS	LEOS	
337214	LEOS	LEOS	LEOS	LEOS	
337215	LEOS	LEOS	SEOS	LEOS	
337910	LEOS	LEOS	LEOS	LEOS	
337920	LEOS	LEOS	LEOS	LEOS	
339 Miscellaneous Manufacturing					durable
339111	LEOS	LEOS	SEOS	SEOS	
339112	SEOS	SEOS	SEOS	SEOS	
339113	LEOS	LEOS	SEOS	LEOS	
339114	SEOS	SEOS	SEOS	SEOS	
339115	SEOS	SEOS	LEOS	LEOS	
339911	LEOS	LEOS	SEOS	LEOS	
339912	LEOS	LEOS	LEOS	LEOS	
339913	SEOS	SEOS		SEOS	
339914	LEOS	LEOS	SEOS	SEOS	
339920	SEOS	LEOS	SEOS	SEOS	
339931	LEOS	LEOS	SEOS	SEOS	
339932	LEOS	LEOS	LEOS	LEOS	
339941	LEOS	LEOS	SEOS	LEOS	

Continued on next page

Table TA1 – continued from previous page

	Uninstrumented		Uninstrumented		
6 Digit NAICS	Benchmark	Alternative	Benchmark	Alternative	Classification
339942	SEOS	SEOS	LEOS	LEOS	
339943	LEOS	LEOS	LEOS	LEOS	
339944	SEOS	LEOS	SEOS	SEOS	
339950	LEOS	LEOS	SEOS	LEOS	
339991	LEOS	LEOS	SEOS	LEOS	
339992	LEOS	SEOS	LEOS	LEOS	
339993	SEOS	LEOS	SEOS	SEOS	
339994	SEOS	SEOS	LEOS	LEOS	
339995	SEOS	SEOS	SEOS	SEOS	
339999	LEOS	LEOS	LEOS	LEOS	

Table TA2: Cost Structure Estimation: Uninstrumented

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
311111	0.936	(0.092)	1.022	(0.086)	0.917	(0.142)	0.983	(0.150)	1.012	(0.320)	0.862	(2.334)
311119			0.092	(4.263)	0.805	(0.094)	0.783	(0.087)	0.762	(0.090)		
311211	0.524	(0.276)	0.391	(0.249)	0.222	(0.073)	0.193	(0.056)	0.216	(0.078)	3.124	(9.392)
311212	0.663	(0.095)	0.505	(0.080)	0.264	(0.087)	0.272	(0.082)	0.336	(0.081)	2.016	(2.158)
311213	0.009	(0.089)	0.006	(0.056)	0.143	(0.074)	0.148	(0.076)	0.110	(0.061)		
311221	0.209	(0.207)	0.129	(0.129)	0.180	(0.110)	0.174	(0.108)	0.143	(0.125)		
311222	0.476	(0.228)	0.234	(0.125)	0.455	(0.098)	0.454	(0.096)	0.438	(0.105)		
311223	0.426	(2.425)			0.727	(0.068)	0.729	(0.065)	0.690	(0.077)		
311225	0.584	(0.680)			0.739	(0.100)	0.738	(0.099)	0.723	(0.103)		
311230	0.668	(0.378)	0.512	(0.248)	0.545	(0.365)	0.539	(0.368)	0.532	(0.316)		
311311	1.124	(0.207)	1.020	(0.065)	1.061	(0.121)	1.147	(0.118)	0.662	(0.158)		
311312	0.885	(0.087)	1.081	(0.169)	0.890	(0.075)	0.904	(0.100)	0.718	(0.075)	0.587	(0.185)
311313	1.111	(0.094)	1.041	(0.053)	1.121	(0.097)	1.106	(0.097)	1.047	(0.106)	1.161	(0.702)
311320	0.326	(0.266)	0.130	(0.127)	0.540	(0.086)	0.542	(0.157)	0.402	(0.141)	0.264	(0.836)
311330	0.941	(0.114)	0.618	(0.089)	0.673	(0.075)	0.746	(0.086)	0.626	(0.067)	0.317	(0.485)
311340	1.087	(0.082)	1.018	(0.028)	1.088	(0.074)	1.080	(0.090)	0.812	(0.144)	0.765	(0.080)
311411	0.694	(3.711)	0.03	(1.189)	0.759	(0.112)	0.748	(0.169)	0.576	(0.150)	0.560	(0.405)
311412	1.197	(0.172)	1.078	(0.100)	1.212	(0.175)	1.234	(0.190)	0.917	(0.156)	0.912	(0.128)
311421	2.491	(9.083)			0.669	(0.070)	0.636	(0.081)	0.457	(0.081)		
311422	0.985	(0.133)	1.001	(0.022)	0.982	(0.165)	0.975	(0.231)	0.717	(0.159)		
311423	1.358	(0.145)	1.172	(0.097)	1.354	(0.156)	1.334	(0.163)	1.120	(0.119)	1.211	(0.352)
311511	0.526	(0.756)	0.085	(0.029)	0.380	(0.167)	0.353	(0.157)	0.127	(0.137)		
311512	1.054	(3.249)			0.653	(0.188)	0.654	(0.195)	0.444	(0.210)	0.406	(0.527)
311513	0.259	(0.165)	0.162	(0.103)	0.474	(0.158)	0.482	(0.160)	0.430	(0.134)		
311514	0.907	(0.089)	1.057	(0.168)	0.877	(0.141)	0.866	(0.184)	0.504	(0.155)		
311520	1.146	(0.134)	1.030	(0.047)	1.129	(0.120)	1.111	(0.128)	0.607	(0.140)		
311611	0.796	(0.255)	0.558	(0.168)	0.646	(0.161)	0.65	(0.171)	0.582	(0.187)	0.045	(3.069)
311612	1.116	(0.285)	1.015	(0.063)	1.050	(0.119)	1.079	(0.139)	0.974	(0.165)	0.916	(0.408)
311613	0.520	(0.140)	0.179	(0.087)	0.499	(0.105)	0.505	(0.111)	0.145	(0.120)		
311615	1.449	(17.433)			0.807	(0.146)	0.813	(0.150)	0.686	(0.125)	0.637	(0.423)
311711	0.946	(0.134)	1.014	(0.080)	0.944	(0.136)	0.936	(0.102)	0.830	(0.095)	0.569	(0.393)
311712	0.736	(1.066)	1.156	(1.336)	0.921	(0.115)	0.911	(0.117)	0.887	(0.084)		
311812	0.836	(0.144)	1.074	(0.166)	0.868	(0.099)	0.833	(0.123)	0.500	(0.096)	0.369	(0.153)
311813	1.287	(0.070)	1.121	(0.041)	1.302	(0.066)	1.349	(0.079)	0.627	(0.180)		
311821			0.250	(1.529)	0.825	(0.119)	0.767	(0.098)	0.675	(0.137)	0.187	(1.154)
311822	0.807	(0.482)	1.256	(2.330)	0.835	(0.372)	0.848	(0.371)	0.623	(0.296)	0.489	(0.676)
311823	1.109	(0.196)	1.023	(0.069)	1.106	(0.187)	1.109	(0.184)	0.743	(0.143)	0.716	(0.106)
311830	1.414	(0.089)	1.157	(0.045)	1.346	(0.067)	1.319	(0.067)	1.297	(0.160)		

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
311911	0.818	(0.087)	2.105	(5.011)	0.753	(0.127)	0.759	(0.135)	0.407	(0.186)		
311919	1.274	(0.328)	1.094	(0.171)	1.274	(0.328)	1.273	(0.324)	1.142	(0.452)	1.569	(3.980)
311920												
311930	0.838	(0.199)	1.078	(0.259)	0.860	(0.162)	0.934	(0.172)	0.348	(0.084)		
311941	1.275	(0.093)	1.104	(0.051)	1.274	(0.089)	1.273	(0.085)	0.820	(0.224)		
311942	1.411	(0.073)	1.156	(0.038)	1.415	(0.069)	1.413	(0.072)	1.081	(0.341)	1.166	(0.871)
311991	1.352	(0.038)	1.131	(0.017)	1.335	(0.027)	1.325	(0.025)	1.235	(0.131)	2.455	(2.96)
311999	1.323	(0.042)	1.146	(0.022)	1.417	(0.030)	1.440	(0.033)	1.361	(0.223)	3.524	(8.744)
312111	0.696	(0.088)	1.682	(1.361)	0.683	(0.130)	0.717	(0.153)	0.314	(0.088)	0.196	(0.152)
312112	1.050	(0.564)	1.001	(0.028)	1.018	(0.208)	0.824	(0.157)	0.772	(0.225)		
312113	0.809	(0.138)	1.129	(0.293)	0.841	(0.126)	1.019	(0.127)	0.378	(0.229)		
312120	0.853	(0.625)	1.045	(0.410)	0.931	(0.207)	0.861	(0.229)	0.728	(0.129)	0.395	(0.928)
312130	0.777	(0.168)	1.222	(0.560)	0.786	(0.144)	0.774	(0.138)	0.475	(0.098)	0.250	(0.237)
312140	0.915	(0.073)	1.051	(0.123)	0.883	(0.105)	0.868	(0.082)	0.463	(0.181)		
312210	1.099	(0.102)	1.015	(0.028)	1.076	(0.085)	1.058	(0.078)	0.993	(0.129)	0.954	(0.747)
312221	0.970	(0.513)	0.999	(0.037)	1.011	(0.165)	0.876	(0.198)	1.105	(0.170)	0.887	(0.158)
312229	1.200	(0.338)	1.038	(0.124)	1.092	(0.207)	1.136	(0.246)	0.947	(0.180)	0.897	(0.275)
313111	0.999	(0.026)	1.000	(0.000)	0.999	(0.050)	0.952	(0.063)	0.828	(0.101)	0.797	(0.101)
313112	0.818	(0.300)	1.117	(0.369)	0.935	(0.039)	0.944	(0.043)	0.909	(0.031)	0.502	(0.635)
313113	1.231	(0.077)	1.106	(0.053)	1.242	(0.093)	1.242	(0.094)	1.050	(0.118)	1.076	(0.227)
313210	0.995	(0.085)	1.000	(0.002)	0.998	(0.040)	1.040	(0.038)	0.959	(0.042)	0.902	(0.065)
313221	1.078	(0.045)	1.013	(0.013)	1.063	(0.039)	1.048	(0.032)	0.938	(0.055)	0.830	(0.080)
313222	1.517	(0.135)	1.263	(0.082)	1.411	(0.081)	1.395	(0.092)	1.380	(0.066)		
313230	0.938	(0.167)	1.014	(0.088)	0.944	(0.155)	0.934	(0.155)	0.755	(0.172)	0.585	(0.309)
313241	1.288	(0.052)	1.120	(0.029)	1.248	(0.038)	1.259	(0.041)	1.198	(0.031)	2.107	(1.033)
313249	1.334	(0.094)	1.134	(0.060)	1.246	(0.085)	1.281	(0.091)	1.153	(0.081)	1.419	(0.554)
313311	1.056	(0.055)	1.010	(0.019)	1.067	(0.071)	1.079	(0.070)	0.965	(0.039)	0.907	(0.088)
313312	1.180	(0.071)	1.060	(0.038)	1.164	(0.076)	1.177	(0.072)	1.070	(0.076)	1.214	(0.407)
313320	1.158	(0.057)	1.028	(0.021)	1.099	(0.051)	1.176	(0.044)	0.935	(0.040)	0.877	(0.058)
314110	1.127	(0.116)	1.027	(0.040)	1.090	(0.081)	1.103	(0.089)	1.038	(0.079)	1.194	(0.689)
314121	1.275	(0.110)	1.115	(0.068)	1.293	(0.122)	1.303	(0.130)	1.021	(0.086)	1.031	(0.139)
314129	1.141	(0.039)	1.036	(0.020)	1.117	(0.048)	1.148	(0.045)	0.984	(0.039)	0.967	(0.073)
314911	0.922	(0.050)	1.038	(0.067)	0.898	(0.073)	0.92	(0.082)	0.746	(0.118)	0.544	(0.199)
314912	1.306	(0.114)	1.113	(0.065)	1.280	(0.114)	1.283	(0.108)	1.050	(0.176)	1.101	(0.435)
314991	0.955	(0.233)	1.003	(0.039)	0.976	(0.131)	1.039	(0.119)	0.847	(0.196)	0.703	(0.169)
314992	1.142	(0.115)	1.048	(0.074)	1.118	(0.149)	1.132	(0.119)	1.049	(0.104)	1.136	(0.491)
314999	1.239	(0.100)	1.082	(0.044)	1.198	(0.056)	1.212	(0.053)	1.129	(0.065)	1.586	(0.831)
315111	1.259	(0.071)	1.138	(0.049)	1.302	(0.072)	1.303	(0.079)	1.175	(0.112)	1.374	(0.602)
315119	1.321	(0.091)	1.152	(0.055)	1.254	(0.074)	1.269	(0.070)	1.176	(0.076)	1.515	(0.744)

Continued on next page

Table TA2 – continued from previous page

NAICS	Benchmark γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	Alternative γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
315191	1.307	(0.065)	1.160	(0.041)	1.367	(0.056)	1.395	(0.060)	1.338	(0.105)	3.148	(5.133)
315192	1.300	(0.064)	1.163	(0.046)	1.334	(0.070)	1.315	(0.078)	1.257	(0.168)	2.249	(4.685)
315221	1.625	(0.061)	1.376	(0.048)	1.504	(0.076)	1.576	(0.069)	1.443	(0.061)	2.078	(0.823)
315222	1.284	(0.091)	1.091	(0.050)	1.159	(0.067)	1.264	(0.076)	1.082	(0.068)	1.149	(0.188)
315223	1.354	(0.054)	1.171	(0.038)	1.312	(0.057)	1.313	(0.052)	1.264	(0.064)	2.751	(3.273)
315224	1.356	(0.044)	1.200	(0.032)	1.399	(0.050)	1.408	(0.063)	1.370	(0.112)	4.201	(11.822)
315225	1.127	(0.048)	1.049	(0.027)	1.176	(0.058)	1.191	(0.064)	1.086	(0.118)	1.244	(0.627)
315228	1.238	(0.063)	1.092	(0.036)	1.205	(0.055)	1.218	(0.052)	1.125	(0.090)	1.426	(0.752)
315231	1.169	(0.023)	1.056	(0.011)	1.212	(0.023)	1.221	(0.028)	0.927	(0.053)	0.89	(0.061)
315232	1.113	(0.103)	1.024	(0.034)	1.112	(0.080)	1.132	(0.058)	1.008	(0.135)	1.026	(0.488)
315233	1.300	(0.088)	1.110	(0.045)	1.282	(0.073)	1.231	(0.063)	0.864	(0.118)	0.829	(0.096)
315234	1.177	(0.100)	1.052	(0.046)	1.200	(0.106)	1.217	(0.074)	0.804	(0.098)	0.763	(0.068)
315239	1.120	(0.047)	1.031	(0.020)	1.139	(0.054)	1.183	(0.039)	0.766	(0.100)	0.759	(0.047)
315291	1.208	(0.043)	1.075	(0.021)	1.206	(0.034)	1.265	(0.076)	0.985	(0.080)	0.979	(0.104)
315292	1.209	(0.104)	1.056	(0.045)	1.146	(0.074)	1.162	(0.075)	1.081	(0.072)	1.382	(0.750)
315299	1.158	(0.060)	1.041	(0.026)	1.127	(0.052)	1.135	(0.066)	0.951	(0.102)	0.904	(0.149)
315991	1.270	(0.125)	1.103	(0.067)	1.227	(0.093)	1.200	(0.099)	1.062	(0.102)	1.158	(0.389)
315992	1.171	(0.086)	1.060	(0.047)	1.168	(0.088)	1.141	(0.083)	0.981	(0.084)	0.964	(0.143)
315993	1.217	(0.109)	1.057	(0.045)	1.178	(0.086)	1.141	(0.08)	1.083	(0.125)	1.678	(2.633)
315999	1.127	(0.053)	1.034	(0.021)	1.144	(0.049)	1.148	(0.047)	1.054	(0.061)	1.236	(0.432)
316110	1.775	(11.451)	0.905	(0.428)	0.947	(0.167)	0.952	(0.188)	0.946	(0.178)		
316211	1.179	(0.089)	1.064	(0.049)	1.183	(0.091)	1.170	(0.083)	1.011	(0.137)	1.023	(0.299)
316212	1.281	(0.054)	1.122	(0.032)	1.317	(0.054)	1.450	(0.080)	1.166	(0.311)	1.272	(0.809)
316213	1.278	(0.061)	1.097	(0.038)	1.180	(0.069)	1.217	(0.075)	1.090	(0.050)	1.228	(0.248)
316214	1.399	(0.123)	1.187	(0.077)	1.315	(0.092)	1.246	(0.067)	1.224	(0.128)	4.185	(22.127)
316219	1.468	(0.118)	1.286	(0.091)	1.598	(0.157)	1.649	(0.205)	1.264	(0.185)	1.294	(0.367)
316991	1.174	(0.143)	1.045	(0.062)	1.160	(0.143)	1.147	(0.129)	0.981	(0.065)	0.947	(0.160)
316992	1.380	(0.137)	1.168	(0.083)	1.372	(0.129)	1.497	(0.061)	0.804	(0.194)		
316993	1.164	(0.181)	1.052	(0.088)	1.219	(0.228)	1.271	(0.229)	0.516	(0.118)		
316999	1.316	(0.062)	1.121	(0.034)	1.279	(0.053)	1.302	(0.059)	1.062	(0.078)	1.115	(0.183)
321113	0.907	(0.066)	1.144	(0.475)	0.896	(0.098)	0.905	(0.095)	0.818	(0.105)	0.645	(0.412)
321114	1.023	(0.075)	1.002	(0.010)	1.021	(0.072)	1.032	(0.071)	0.655	(0.084)		
321211	1.087	(0.101)	1.017	(0.034)	1.057	(0.066)	1.048	(0.054)	1.025	(0.076)	1.241	(1.611)
321212	1.102	(0.049)	1.040	(0.026)	1.105	(0.035)	1.116	(0.045)	0.963	(0.111)	0.960	(0.091)
321213	1.237	(0.046)	1.075	(0.024)	1.208	(0.047)	1.224	(0.050)	0.900	(0.092)	0.863	(0.089)
321214	1.168	(0.026)	1.046	(0.010)	1.169	(0.021)	1.166	(0.027)	0.986	(0.053)	0.965	(0.121)
321219	1.041	(0.102)	1.004	(0.018)	1.030	(0.072)	1.070	(0.095)	0.913	(0.098)	0.846	(0.111)
321911	1.291	(0.071)	1.107	(0.039)	1.214	(0.059)	1.235	(0.050)	1.131	(0.050)	1.451	(0.438)
321912	1.001	(0.044)	1.000	(0.000)	1.001	(0.046)	1.008	(0.047)	0.891	(0.056)	0.800	(0.071)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
321918	1.236	(0.059)	1.083	(0.029)	1.181	(0.053)	1.204	(0.042)	1.119	(0.055)	1.452	(0.541)
321920	1.188	(0.420)	0.866	(0.067)	0.874	(0.142)	0.973	(0.152)	0.869	(0.086)	0.685	(0.416)
321991	1.278	(0.027)	1.103	(0.012)	1.220	(0.018)	1.247	(0.019)	1.154	(0.029)	1.598	(0.321)
321992	1.179	(0.029)	1.041	(0.009)	1.144	(0.017)	1.165	(0.024)	1.028	(0.031)	1.098	(0.133)
321999	0.963	(0.121)	1.004	(0.032)	0.971	(0.097)	0.964	(0.096)	0.871	(0.099)	0.629	(0.362)
322110	0.934	(0.167)	1.008	(0.037)	0.974	(0.049)	0.967	(0.046)	0.958	(0.049)		
322121			1.530	(2.527)	1.129	(0.100)	1.140	(0.158)	1.156	(0.130)		
322122	0.813	(0.498)	1.118	(0.693)	0.922	(0.175)	0.929	(0.192)	0.888	(0.215)	0.365	(3.565)
322130	1.037	(0.063)	0.994	(0.023)	0.964	(0.075)	1.042	(0.112)	1.030	(0.102)	1.624	(9.011)
322211	0.870	(0.131)	1.073	(0.189)	0.885	(0.100)	0.888	(0.112)	0.745	(0.086)	0.419	(0.411)
322212	1.060	(0.120)	1.009	(0.032)	1.057	(0.116)	1.059	(0.116)	0.880	(0.117)	0.781	(0.137)
322213	1.026	(0.042)	1.004	(0.012)	1.061	(0.096)	0.765	(0.155)	0.345	(0.180)		
322214	1.192	(0.066)	1.069	(0.037)	1.184	(0.064)	1.184	(0.076)	0.832	(0.156)		
322215	0.986	(0.100)	1.001	(0.009)	0.989	(0.080)	0.978	(0.081)	0.424	(0.152)		
322221	1.076	(0.054)	1.011	(0.015)	1.063	(0.053)	1.082	(0.040)	0.878	(0.039)	0.765	(0.048)
322222	1.367	(0.105)	1.141	(0.059)	1.331	(0.104)	1.337	(0.101)	1.169	(0.135)	1.528	(0.890)
322223	1.150	(0.115)	1.048	(0.058)	1.174	(0.133)	1.155	(0.123)	0.839	(0.084)	0.810	(0.072)
322224	1.030	(0.114)	1.003	(0.019)	1.025	(0.101)	1.033	(0.104)	0.933	(0.080)	0.821	(0.182)
322225	1.205	(0.037)	1.068	(0.020)	1.202	(0.046)	1.196	(0.040)	1.026	(0.045)	1.061	(0.122)
322226	1.112	(0.117)	1.025	(0.046)	1.110	(0.121)	1.106	(0.118)	0.845	(0.073)	0.780	(0.087)
322231	1.253	(0.069)	1.092	(0.039)	1.241	(0.073)	1.238	(0.077)	1.014	(0.112)	1.025	(0.219)
322232	1.197	(0.061)	1.057	(0.027)	1.157	(0.044)	1.162	(0.054)	1.016	(0.044)	1.042	(0.127)
322233	1.057	(0.081)	1.009	(0.025)	1.072	(0.112)	1.077	(0.111)	0.986	(0.107)	0.941	(0.378)
322291	1.269	(0.053)	1.147	(0.035)	1.387	(0.067)	1.330	(0.066)	1.195	(0.107)	1.485	(0.685)
322299	1.437	(0.048)	1.200	(0.031)	1.423	(0.052)	1.425	(0.052)	1.344	(0.067)	3.104	(2.485)
323110	1.690	(0.170)	1.236	(0.046)	1.300	(0.034)	1.347	(0.046)	1.285	(0.031)	3.09	(1.938)
323111	1.121	(0.042)	1.036	(0.020)	1.123	(0.041)	1.152	(0.058)	0.486	(0.166)		
323112	1.337	(0.044)	1.153	(0.027)	1.397	(0.046)	1.410	(0.033)	0.932	(0.160)	0.928	(0.144)
323113	1.078	(0.089)	1.017	(0.031)	1.098	(0.102)	1.100	(0.089)	0.777	(0.145)	0.744	(0.072)
323114	1.083	(0.136)	1.018	(0.049)	1.104	(0.160)	1.103	(0.174)	1.057	(0.191)	1.466	(3.896)
323115	1.317	(0.079)	1.143	(0.050)	1.381	(0.096)	1.381	(0.047)	1.306	(0.076)	2.978	(2.744)
323116	1.455	(0.093)	1.181	(0.047)	1.335	(0.059)	1.350	(0.078)	1.235	(0.049)	1.965	(0.861)
323117	1.105	(0.072)	1.027	(0.032)	1.112	(0.080)	1.119	(0.075)	0.837	(0.128)	0.810	(0.074)
323118	1.398	(0.078)	1.169	(0.045)	1.377	(0.070)	1.241	(0.047)	1.020	(0.166)	1.041	(0.370)
323119	1.000	(0.054)	1.000	(0.000)	1.001	(0.078)	1.007	(0.076)	0.838	(0.112)	0.659	(0.129)
323121	0.825	(0.313)	1.259	(1.574)	0.865	(0.185)	0.874	(0.193)	0.783	(0.148)	0.429	(1.219)
323122	0.970	(0.023)	1.004	(0.007)	0.964	(0.033)	0.990	(0.034)	0.839	(0.079)	0.653	(0.067)
324110	0.673	(0.118)	0.412	(0.092)	0.438	(0.050)	0.444	(0.047)	0.430	(0.057)		
324121	1.045	(0.115)	1.004	(0.020)	1.036	(0.096)	1.055	(0.093)	0.843	(0.094)	0.739	(0.100)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
324122			1.146	(0.954)	1.041	(0.099)	1.041	(0.093)	1.059	(0.107)		
324191	1.075	(0.121)	1.010	(0.029)	1.095	(0.152)	0.995	(0.154)	0.619	(0.129)	0.424	(0.146)
324199	1.102	(0.181)	0.798	(0.104)	0.787	(0.109)	0.790	(0.144)	0.791	(0.097)		
325110	0.785	(1.156)	1.027	(0.291)	0.962	(0.124)	1.233	(0.181)	0.880	(0.081)	0.818	(0.105)
325120	1.445	(0.186)	1.183	(0.097)	1.460	(0.146)	1.475	(0.203)	0.572	(0.212)		
325131	1.067	(0.277)	1.006	(0.046)	1.040	(0.177)	1.076	(0.177)	0.886	(0.149)	0.744	(0.239)
325132	0.861	(0.147)	3.129	(9.952)	0.649	(0.174)	0.673	(0.152)	0.518	(0.160)	0.089	(0.937)
325181	2.330	(0.324)	1.670	(0.155)	1.838	(0.167)	1.932	(0.187)	1.716	(0.152)	3.265	(2.700)
325182	1.337	(0.190)	1.147	(0.105)	1.308	(0.133)	1.292	(0.136)	1.086	(0.189)	1.162	(0.513)
325188	1.561	(0.090)	1.235	(0.049)	1.554	(0.082)	1.583	(0.101)	0.759	(0.181)		
325191	1.251	(0.321)	1.098	(0.180)	1.265	(0.310)	1.306	(0.331)	0.656	(0.348)		
325192	0.872	(0.182)	1.056	(0.192)	0.886	(0.137)	0.887	(0.139)	0.768	(0.104)	0.256	(0.817)
325193	1.126	(0.196)	1.027	(0.074)	1.135	(0.225)	1.126	(0.139)	0.637	(0.175)		
325199	1.767	(0.356)	1.174	(0.082)	1.230	(0.179)	1.274	(0.149)	1.204	(0.123)	2.636	(5.040)
325211	1.547	(1.215)	1.080	(0.172)	1.113	(0.145)	1.141	(0.186)	1.103	(0.156)	2.332	(9.940)
325212	1.059	(0.107)	1.007	(0.022)	1.055	(0.091)	1.057	(0.098)	0.902	(0.098)	0.734	(0.173)
325221	1.339	(0.126)	1.119	(0.063)	1.225	(0.083)	1.175	(0.133)	1.165	(0.094)		
325222	1.140	(0.197)	1.026	(0.069)	1.087	(0.158)	1.135	(0.143)	0.982	(0.108)	0.955	(0.245)
325311	0.980	(0.357)	1.001	(0.020)	0.989	(0.181)	0.987	(0.189)	0.882	(0.119)	0.557	(0.708)
325312	1.107	(0.209)	1.026	(0.090)	1.118	(0.267)	1.110	(0.238)	0.884	(0.134)	0.808	(0.194)
325314	1.821	(0.448)	1.444	(0.312)	2.034	(0.606)	1.920	(0.606)	1.139	(0.505)	1.165	(0.710)
325320	0.973	(0.197)	1.001	(0.019)	0.977	(0.161)	0.999	(0.160)	0.632	(0.124)	0.484	(0.143)
325411	1.511	(0.135)	1.173	(0.062)	1.400	(0.093)	1.339	(0.135)	0.953	(0.070)	0.915	(0.112)
325412	0.896	(0.350)	1.021	(0.168)	0.907	(0.327)	0.821	(0.201)	0.242	(0.175)		
325413	1.471	(0.098)	1.153	(0.040)	1.464	(0.073)	1.470	(0.091)	1.013	(0.107)	1.028	(0.233)
325414	1.255	(0.163)	1.072	(0.066)	1.301	(0.157)	1.391	(0.116)	0.640	(0.313)	0.594	(0.186)
325510	1.172	(0.163)	1.036	(0.057)	1.172	(0.166)	1.173	(0.133)	0.782	(0.146)	0.632	(0.138)
325520	1.252	(0.161)	1.078	(0.074)	1.292	(0.166)	1.328	(0.154)	0.648	(0.157)	0.646	(0.086)
325611	0.674	(0.419)	0.401	(0.221)	0.337	(0.323)	0.149	(0.450)	0.450	(0.156)	1.123	(0.562)
325612	0.826	(0.271)	1.160	(0.932)	0.796	(0.386)	0.789	(0.400)	0.079	(0.198)		
325613	1.494	(0.217)	1.154	(0.103)	1.378	(0.189)	1.441	(0.241)	0.955	(0.176)	0.925	(0.267)
325620	1.399	(0.313)	1.127	(0.149)	1.341	(0.272)	1.297	(0.302)	0.762	(0.248)	0.698	(0.202)
325910	1.069	(0.137)	1.009	(0.031)	1.078	(0.145)	1.082	(0.144)	0.730	(0.178)	0.589	(0.130)
325920	1.200	(0.045)	1.051	(0.022)	1.165	(0.060)	1.176	(0.043)	0.998	(0.069)	0.994	(0.178)
325991	1.209	(0.094)	1.066	(0.044)	1.203	(0.081)	1.193	(0.063)	0.934	(0.098)	0.890	(0.123)
325992	0.983	(0.100)	1.000	(0.006)	0.986	(0.084)	0.982	(0.100)	0.758	(0.182)	0.433	(0.198)
325998	1.046	(0.236)	1.003	(0.026)	1.032	(0.166)	1.093	(0.179)	0.746	(0.127)	0.598	(0.152)
326111	0.995	(0.060)	1.000	(0.003)	0.993	(0.075)	0.974	(0.071)	0.791	(0.047)	0.656	(0.109)
326112	1.136	(0.106)	1.027	(0.037)	1.094	(0.081)	1.120	(0.069)	1.003	(0.095)	1.009	(0.319)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
326113	1.469	(0.078)	1.153	(0.025)	1.263	(0.054)	1.345	(0.038)	1.198	(0.030)	1.673	(0.287)
326121	1.317	(0.063)	1.108	(0.028)	1.261	(0.063)	1.307	(0.037)	1.092	(0.041)	1.214	(0.138)
326122	1.194	(0.165)	1.051	(0.066)	1.142	(0.118)	1.162	(0.126)	1.064	(0.138)	1.259	(0.974)
326130	1.438	(0.057)	1.190	(0.030)	1.364	(0.037)	1.409	(0.040)	1.208	(0.039)	1.481	(0.201)
326140	1.173	(0.118)	1.042	(0.047)	1.122	(0.083)	1.154	(0.103)	1.012	(0.094)	1.032	(0.272)
326150	1.348	(0.058)	1.092	(0.015)	1.168	(0.026)	1.231	(0.037)	1.119	(0.028)	1.452	(0.257)
326160	1.186	(0.103)	1.070	(0.055)	1.162	(0.076)	1.176	(0.097)	1.055	(0.078)	1.120	(0.261)
326191	1.372	(0.100)	1.178	(0.059)	1.433	(0.090)	1.389	(0.095)	1.022	(0.131)	1.029	(0.180)
326192	1.327	(0.062)	1.149	(0.037)	1.323	(0.053)	1.332	(0.071)	1.036	(0.074)	1.048	(0.109)
326199	1.481	(0.109)	1.142	(0.020)	1.216	(0.061)	1.340	(0.046)	1.172	(0.029)	1.476	(0.200)
326211	1.022	(0.107)	1.001	(0.011)	1.013	(0.067)	1.086	(0.065)	0.920	(0.054)	0.875	(0.060)
326220	1.264	(0.090)	1.089	(0.046)	1.222	(0.076)	1.237	(0.085)	1.001	(0.084)	1.002	(0.151)
326291	1.181	(0.076)	1.038	(0.040)	1.104	(0.091)	1.239	(0.049)	0.976	(0.030)	0.963	(0.042)
326299	1.253	(0.082)	1.092	(0.046)	1.255	(0.090)	1.247	(0.083)	0.950	(0.075)	0.924	(0.094)
327111			3.612	(57.199)	1.166	(0.124)	1.358	(0.126)	1.261	(0.111)	1.750	(1.488)
327112	1.376	(0.133)	1.153	(0.078)	1.271	(0.100)	1.194	(0.086)	1.220	(0.092)		
327113	1.617	(0.081)	1.291	(0.047)	1.461	(0.053)	1.457	(0.074)	1.290	(0.097)	1.812	(0.815)
327121	1.267	(0.044)	1.100	(0.024)	1.204	(0.047)	1.250	(0.033)	1.094	(0.053)	1.200	(0.185)
327122	1.009	(0.137)	1.000	(0.008)	1.009	(0.129)	1.024	(0.117)	0.696	(0.080)		
327123	1.190	(0.138)	1.055	(0.073)	1.138	(0.135)	1.181	(0.138)	1.015	(0.080)	1.030	(0.176)
327124	1.545	(0.086)	1.286	(0.061)	1.528	(0.091)	1.520	(0.093)	1.241	(0.117)	1.408	(0.386)
327125	1.749	(0.121)	1.361	(0.069)	1.556	(0.097)	1.594	(0.110)	1.391	(0.099)	2.048	(0.919)
327211	0.534	(1.113)	0.743	(0.928)	1.141	(0.093)	1.436	(0.094)	1.318	(0.058)	1.833	(0.829)
327212	1.234	(0.148)	1.094	(0.090)	1.184	(0.123)	1.248	(0.124)	0.951	(0.137)		
327213	0.673	(1.662)			0.861	(0.096)	0.857	(0.094)	0.828	(0.091)	0.173	(3.409)
327215	1.155	(0.067)	1.036	(0.032)	1.107	(0.071)	1.150	(0.049)	0.989	(0.038)	0.976	(0.078)
327310	1.479	(0.235)	1.191	(0.130)	1.267	(0.144)	1.364	(0.138)	1.204	(0.152)	1.472	(0.88)
327320	1.351	(0.089)	1.152	(0.040)	1.324	(0.037)	1.310	(0.034)	1.273	(0.066)	4.093	(6.934)
327331	1.213	(0.043)	1.062	(0.019)	1.223	(0.045)	1.215	(0.044)	0.903	(0.071)	0.830	(0.088)
327332	1.437	(0.084)	1.180	(0.056)	1.336	(0.104)	1.352	(0.097)	1.039	(0.101)	1.057	(0.165)
327390	1.400	(0.092)	1.181	(0.057)	1.385	(0.089)	1.404	(0.094)	1.162	(0.102)	1.312	(0.344)
327410	1.171	(0.153)	1.056	(0.078)	1.147	(0.128)	1.139	(0.102)	0.982	(0.138)	0.967	(0.228)
327420	1.377	(0.089)	1.128	(0.049)	1.178	(0.073)	1.298	(0.069)	1.135	(0.055)	1.270	(0.226)
327910	1.700	(0.118)	1.321	(0.072)	1.637	(0.110)	1.644	(0.114)	1.198	(0.116)	1.324	(0.280)
327991	1.357	(0.074)	1.181	(0.042)	1.371	(0.045)	1.381	(0.042)	1.288	(0.059)	2.132	(1.056)
327992	1.125	(0.320)	1.033	(0.136)	1.130	(0.313)	1.149	(0.325)	0.796	(0.285)	0.787	(0.185)
327993	1.545	(0.115)	1.309	(0.075)	1.477	(0.084)	1.509	(0.090)	1.306	(0.107)	1.535	(0.514)
327999	0.102	(8.406)			0.846	(0.190)	0.925	(0.188)	0.78	(0.138)	0.526	(0.541)
331111	0.868	(0.489)	0.974	(0.140)	1.050	(0.082)	1.277	(0.065)	1.129	(0.042)	1.268	(0.193)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
331112	1.156	(0.126)	1.033	(0.034)	1.091	(0.042)	1.155	(0.088)	1.004	(0.09)	1.009	(0.204)
331210	1.327	(0.106)	1.148	(0.056)	1.316	(0.061)	1.321	(0.089)	1.174	(0.096)	1.452	(0.593)
331221	1.263	(0.091)	1.074	(0.046)	1.150	(0.073)	1.231	(0.084)	1.078	(0.052)	1.190	(0.210)
331222	1.436	(0.132)	1.191	(0.069)	1.333	(0.083)	1.391	(0.106)	1.202	(0.079)	1.439	(0.412)
331311	1.242	(0.446)	0.782	(0.078)	0.734	(0.174)	0.919	(0.095)	0.764	(0.079)	0.370	(0.338)
331312	1.133	(0.123)	0.931	(0.095)	0.901	(0.101)	1.060	(0.147)	0.927	(0.111)	0.851	(0.178)
331314	0.801	(0.184)	1.625	(2.005)	0.775	(0.076)	0.773	(0.055)	0.673	(0.032)	0.066	(0.490)
331315	1.038	(0.092)	0.863	(0.072)	0.775	(0.121)	0.985	(0.152)	0.860	(0.109)	0.695	(0.323)
331316	1.148	(0.118)	1.035	(0.050)	1.105	(0.099)	1.160	(0.090)	1.000	(0.089)	1.001	(0.191)
331319	1.223	(0.044)	1.078	(0.024)	1.198	(0.044)	1.202	(0.034)	1.114	(0.045)	1.468	(0.455)
331411	1.034	(0.042)	1.004	(0.009)	1.033	(0.040)	1.049	(0.042)	0.929	(0.063)	0.850	(0.072)
331419	0.708	(0.329)			0.738	(0.173)	0.743	(0.167)	0.642	(0.160)	0.037	(1.779)
331421	1.037	(0.113)	1.003	(0.017)	1.024	(0.085)	1.084	(0.052)	0.918	(0.032)	0.847	(0.051)
331422	1.012	(0.102)	1.000	(0.006)	1.010	(0.087)	1.027	(0.070)	0.901	(0.044)	0.734	(0.133)
331423	0.825	(0.022)	2.662	(4.423)	0.705	(0.084)	0.686	(0.090)	0.328	(0.185)		
331491	0.983	(0.137)	1.000	(0.006)	0.992	(0.060)	1.056	(0.050)	0.916	(0.043)	0.765	(0.088)
331492	0.901	(0.068)	1.054	(0.095)	0.877	(0.078)	0.870	(0.072)	0.762	(0.072)	0.267	(0.505)
331511	1.030	(0.005)	0.986	(0.020)	0.926	(0.068)	1.269	(0.033)	1.125	(0.023)	1.25	(0.101)
331512	1.456	(0.073)	1.231	(0.051)	1.424	(0.076)	1.444	(0.067)	1.181	(0.051)	1.281	(0.145)
331513	1.461	(0.040)	1.251	(0.035)	1.453	(0.080)	1.473	(0.032)	1.180	(0.060)	1.235	(0.129)
331521	1.517	(0.687)	1.115	(0.071)	1.106	(0.085)	1.334	(0.050)	1.113	(0.049)	1.165	(0.112)
331522	1.209	(0.084)	1.083	(0.044)	1.228	(0.069)	1.229	(0.076)	1.025	(0.105)	1.044	(0.205)
331524	1.407	(0.101)	1.191	(0.053)	1.319	(0.101)	1.382	(0.087)	1.195	(0.078)	1.368	(0.336)
331525	1.051	(0.070)	1.008	(0.020)	1.057	(0.080)	1.056	(0.074)	0.841	(0.083)	0.775	(0.069)
331528	1.310	(0.166)	1.089	(0.075)	1.178	(0.111)	1.248	(0.108)	1.086	(0.109)	1.224	(0.454)
332111	1.473	(0.136)	1.184	(0.049)	1.28	(0.048)	1.358	(0.047)	1.205	(0.055)	1.546	(0.374)
332112	1.186	(0.159)	1.053	(0.068)	1.153	(0.116)	1.155	(0.103)	0.977	(0.132)	0.951	(0.242)
332114	1.289	(0.124)	1.089	(0.056)	1.227	(0.089)	1.138	(0.105)	1.066	(0.108)	1.419	(1.432)
332115	1.359	(0.146)	1.155	(0.089)	1.300	(0.124)	1.315	(0.123)	1.115	(0.187)	1.218	(0.571)
332116	1.645	(0.168)	1.249	(0.096)	1.337	(0.126)	1.443	(0.100)	1.287	(0.119)	1.870	(1.137)
332117	1.627	(0.201)	1.189	(0.115)	1.247	(0.140)	1.199	(0.125)	1.221	(0.128)		
332211	1.180	(0.156)	1.062	(0.078)	1.206	(0.151)	1.194	(0.157)	0.785	(0.233)		
332212	1.445	(0.113)	1.168	(0.059)	1.316	(0.091)	1.364	(0.077)	1.184	(0.084)	1.500	(0.495)
332213	1.208	(0.120)	1.053	(0.051)	1.156	(0.100)	1.180	(0.099)	0.911	(0.114)	0.852	(0.134)
332214	1.456	(0.210)	1.203	(0.105)	1.383	(0.116)	1.433	(0.130)	1.221	(0.168)	1.493	(0.806)
332311	1.238	(0.117)	1.068	(0.049)	1.206	(0.087)	1.194	(0.099)	0.921	(0.139)	0.857	(0.182)
332312	1.027	(0.132)	1.001	(0.010)	1.015	(0.081)	1.051	(0.069)	0.942	(0.051)	0.793	(0.146)
332313	1.252	(0.091)	1.058	(0.049)	1.136	(0.101)	1.188	(0.098)	1.013	(0.053)	1.033	(0.142)
332321	1.310	(0.053)	1.095	(0.023)	1.229	(0.039)	1.257	(0.042)	1.074	(0.056)	1.199	(0.216)

Continued on next page

Table TA2 – continued from previous page

NAICS	Benchmark γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	Alternative γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
332322	1.365	(0.083)	1.120	(0.044)	1.239	(0.070)	1.278	(0.073)	1.151	(0.069)	1.546	(0.612)
332323	1.275	(0.119)	1.086	(0.051)	1.216	(0.072)	1.220	(0.092)	1.107	(0.112)	1.437	(0.947)
332410	1.264	(0.122)	1.087	(0.062)	1.238	(0.112)	1.262	(0.112)	1.002	(0.081)	1.004	(0.150)
332420	1.383	(0.050)	1.148	(0.032)	1.315	(0.068)	1.372	(0.044)	1.097	(0.048)	1.174	(0.119)
332431	0.490	(0.317)	0.403	(0.255)	0.332	(0.328)	0.376	(0.321)	0.396	(0.241)	3.358	(51.144)
332439	1.211	(0.093)	1.074	(0.049)	1.207	(0.087)	1.214	(0.096)	0.847	(0.177)	0.841	(0.111)
332510	1.390	(0.034)	1.117	(0.032)	1.206	(0.069)	1.420	(0.029)	1.090	(0.017)	1.133	(0.034)
332611	1.163	(0.068)	1.041	(0.030)	1.127	(0.062)	1.176	(0.054)	0.918	(0.072)	0.879	(0.075)
332612	1.384	(0.099)	1.177	(0.065)	1.35	(0.099)	1.360	(0.105)	1.020	(0.114)	1.024	(0.143)
332618	1.209	(0.065)	1.069	(0.036)	1.205	(0.082)	1.206	(0.050)	1.006	(0.086)	1.013	(0.185)
332710	1.501	(0.326)	1.162	(0.070)	1.212	(0.067)	1.295	(0.067)	1.186	(0.048)	1.654	(0.591)
332721	1.650	(0.051)	1.342	(0.044)	1.527	(0.094)	1.566	(0.055)	1.406	(0.083)	2.136	(0.893)
332722	1.583	(0.078)	1.262	(0.055)	1.436	(0.094)	1.545	(0.069)	1.254	(0.064)	1.455	(0.231)
332811	1.531	(0.237)	1.201	(0.102)	1.316	(0.117)	1.342	(0.120)	1.248	(0.110)	2.203	(2.416)
332812	1.036	(0.747)	0.999	(0.048)	0.991	(0.229)	0.960	(0.292)	1.013	(0.210)	0.928	(1.000)
332813	1.482	(0.203)	1.224	(0.119)	1.404	(0.140)	1.417	(0.133)	1.249	(0.158)	1.661	(1.134)
332911	1.387	(0.097)	1.133	(0.050)	1.319	(0.085)	1.358	(0.078)	1.085	(0.068)	1.184	(0.197)
332912	1.608	(0.170)	1.228	(0.091)	1.386	(0.125)	1.400	(0.111)	1.261	(0.118)	2.045	(1.55)
332913	1.279	(0.105)	1.109	(0.062)	1.287	(0.114)	1.274	(0.103)	0.820	(0.183)		
332919	1.334	(0.094)	1.137	(0.059)	1.338	(0.113)	1.340	(0.107)	1.054	(0.055)	1.093	(0.115)
332991	1.355	(0.042)	1.182	(0.034)	1.361	(0.066)	1.370	(0.036)	1.099	(0.039)	1.127	(0.070)
332992	1.009	(0.185)	1.000	(0.010)	1.008	(0.169)	1.034	(0.171)	0.801	(0.193)	0.734	(0.156)
332993	1.265	(0.102)	1.079	(0.042)	1.279	(0.086)	1.245	(0.071)	1.025	(0.106)	1.074	(0.349)
332994	1.339	(0.170)	1.114	(0.086)	1.242	(0.125)	1.239	(0.096)	1.061	(0.161)	1.153	(0.547)
332995	1.100	(0.175)	1.006	(0.022)	1.044	(0.088)	1.045	(0.103)	0.930	(0.073)	0.624	(0.336)
332996	1.374	(0.145)	1.137	(0.081)	1.271	(0.120)	1.275	(0.128)	1.176	(0.122)	1.776	(1.762)
332997	1.413	(0.077)	1.223	(0.055)	1.38	(0.078)	1.415	(0.065)	1.126	(0.146)	1.141	(0.237)
332998	1.412	(0.115)	1.188	(0.067)	1.364	(0.084)	1.354	(0.082)	1.117	(0.096)	1.208	(0.260)
332999	1.747	(0.563)	1.178	(0.115)	1.195	(0.103)	1.210	(0.093)	1.190	(0.098)		
333111	1.408	(0.064)	1.147	(0.037)	1.285	(0.056)	1.415	(0.059)	1.119	(0.039)	1.204	(0.099)
333112	1.215	(0.040)	1.071	(0.023)	1.201	(0.048)	1.222	(0.041)	0.992	(0.046)	0.985	(0.078)
333120	1.066	(0.380)	1.003	(0.038)	1.019	(0.149)	1.283	(0.078)	0.943	(0.039)	0.918	(0.049)
333131	1.237	(0.077)	1.065	(0.033)	1.210	(0.065)	1.248	(0.070)	0.981	(0.063)	0.960	(0.122)
333132	1.328	(0.051)	1.093	(0.031)	1.235	(0.079)	1.296	(0.069)	1.087	(0.035)	1.240	(0.152)
333210	1.427	(0.100)	1.169	(0.056)	1.413	(0.096)	1.408	(0.097)	1.139	(0.141)	1.323	(0.505)
333220	1.340	(0.039)	1.103	(0.021)	1.29	(0.055)	1.318	(0.039)	1.118	(0.029)	1.391	(0.168)
333291	0.801	(0.198)	1.061	(0.133)	0.906	(0.063)	0.998	(0.073)	0.776	(0.047)	0.499	(0.129)
333292	1.345	(0.069)	1.116	(0.037)	1.304	(0.071)	1.328	(0.052)	0.881	(0.139)	0.842	(0.135)
333293	1.178	(0.066)	1.045	(0.028)	1.203	(0.080)	1.206	(0.078)	0.804	(0.054)	0.696	(0.058)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
333294	1.234	(0.069)	1.053	(0.027)	1.176	(0.058)	1.266	(0.042)	0.911	(0.067)	0.846	(0.088)
333295	1.591	(0.097)	1.215	(0.045)	1.534	(0.075)	1.559	(0.104)	1.279	(0.067)	1.907	(0.516)
333298	1.533	(0.130)	1.222	(0.077)	1.549	(0.150)	1.551	(0.110)	1.303	(0.147)	1.954	(1.091)
333311	1.367	(0.055)	1.127	(0.027)	1.325	(0.046)	1.356	(0.052)	0.865	(0.090)	0.832	(0.082)
333312	1.053	(0.074)	1.006	(0.015)	1.055	(0.075)	1.053	(0.064)	0.542	(0.189)		
333313	1.097	(0.147)	1.012	(0.032)	1.095	(0.138)	1.078	(0.141)	0.592	(0.131)	0.441	(0.094)
333314	1.284	(0.081)	1.081	(0.031)	1.26	(0.052)	1.369	(0.032)	1.231	(0.316)	2.162	(4.259)
333315	1.711	(0.393)	1.232	(0.177)	1.446	(0.251)	1.435	(0.238)	1.348	(0.253)	4.086	(13.704)
333319	1.273	(0.087)	1.067	(0.037)	1.225	(0.085)	1.232	(0.086)	0.939	(0.065)	0.861	(0.121)
333411	1.068	(0.150)	1.007	(0.028)	1.054	(0.116)	1.049	(0.114)	0.711	(0.132)	0.610	(0.093)
333412	1.076	(0.104)	1.008	(0.021)	1.058	(0.078)	1.077	(0.082)	0.796	(0.101)	0.664	(0.085)
333414	1.388	(0.145)	1.151	(0.084)	1.402	(0.162)	1.402	(0.171)	1.000	(0.116)	1.000	(0.184)
333415	1.269	(0.096)	1.052	(0.039)	1.110	(0.079)	1.249	(0.068)	1.039	(0.045)	1.083	(0.117)
333511	1.503	(0.159)	1.221	(0.081)	1.319	(0.083)	1.366	(0.092)	1.279	(0.085)	2.180	(1.904)
333512	1.355	(0.064)	1.126	(0.039)	1.355	(0.088)	1.342	(0.074)	1.067	(0.063)	1.158	(0.186)
333513	1.377	(0.126)	1.085	(0.037)	1.162	(0.050)	1.284	(0.054)	1.097	(0.047)	1.270	(0.211)
333514	1.547	(0.131)	1.280	(0.079)	1.451	(0.106)	1.463	(0.082)	1.394	(0.089)	3.297	(4.320)
333515	1.723	(0.130)	1.334	(0.087)	1.541	(0.134)	1.628	(0.119)	1.382	(0.111)	1.930	(0.790)
333516	1.331	(0.103)	1.113	(0.051)	1.312	(0.095)	1.316	(0.112)	0.998	(0.124)	0.997	(0.230)
333518	1.299	(0.108)	1.082	(0.030)	1.216	(0.041)	1.217	(0.057)	1.116	(0.085)	1.614	(1.021)
333611	1.478	(0.319)	1.145	(0.129)	1.307	(0.167)	1.316	(0.180)	1.187	(0.196)	1.910	(2.593)
333612	1.486	(0.107)	1.202	(0.068)	1.396	(0.117)	1.498	(0.090)	1.118	(0.089)	1.175	(0.176)
333613	1.464	(0.096)	1.183	(0.054)	1.357	(0.077)	1.417	(0.087)	1.158	(0.085)	1.326	(0.297)
333618	1.281	(0.081)	1.095	(0.039)	1.232	(0.065)	1.316	(0.079)	1.008	(0.072)	1.013	(0.112)
333911	1.312	(0.092)	1.075	(0.041)	1.210	(0.086)	1.369	(0.094)	0.954	(0.039)	0.924	(0.058)
333912	1.059	(0.180)	1.003	(0.016)	1.025	(0.084)	1.182	(0.095)	0.862	(0.063)	0.741	(0.087)
333913	1.132	(0.203)	1.016	(0.045)	1.077	(0.130)	1.123	(0.153)	0.818	(0.069)	0.661	(0.135)
333921	1.286	(0.127)	1.091	(0.057)	1.280	(0.105)	1.272	(0.123)	0.845	(0.139)	0.784	(0.130)
333922	1.228	(0.056)	1.055	(0.024)	1.205	(0.060)	1.234	(0.039)	0.805	(0.077)	0.709	(0.065)
333923	1.302	(0.074)	1.100	(0.042)	1.265	(0.084)	1.309	(0.067)	1.001	(0.061)	1.002	(0.107)
333924	1.262	(0.044)	1.074	(0.022)	1.222	(0.049)	1.268	(0.038)	0.969	(0.036)	0.941	(0.060)
333991	1.509	(0.060)	1.236	(0.039)	1.523	(0.096)	1.514	(0.063)	1.160	(0.075)	1.275	(0.191)
333992	1.145	(0.097)	1.023	(0.027)	1.102	(0.070)	1.161	(0.087)	0.870	(0.076)	0.759	(0.095)
333993	1.259	(0.096)	1.070	(0.038)	1.235	(0.078)	1.235	(0.074)	0.917	(0.103)	0.838	(0.153)
333994	1.360	(0.059)	1.107	(0.027)	1.308	(0.055)	1.328	(0.041)	0.891	(0.069)	0.823	(0.085)
333995	1.296	(0.162)	1.076	(0.060)	1.191	(0.093)	1.284	(0.133)	1.029	(0.106)	1.062	(0.255)
333996	1.424	(0.058)	1.162	(0.028)	1.361	(0.056)	1.404	(0.059)	1.097	(0.076)	1.182	(0.190)
333997	1.255	(0.121)	1.071	(0.052)	1.25	(0.112)	1.300	(0.107)	0.776	(0.163)	0.715	(0.123)
333999	1.264	(0.121)	1.067	(0.049)	1.218	(0.105)	1.225	(0.110)	0.967	(0.120)	0.919	(0.255)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
334111	1.586	(0.170)	1.180	(0.079)	1.515	(0.172)	1.530	(0.128)	0.885	(0.160)	0.800	(0.230)
334112	1.355	(0.159)	1.091	(0.061)	1.321	(0.135)	1.321	(0.139)	0.989	(0.180)	0.969	(0.473)
334113	1.367	(0.061)	1.098	(0.021)	1.326	(0.041)	1.322	(0.067)	1.087	(0.102)	1.318	(0.518)
334119	1.242	(0.183)	1.055	(0.064)	1.253	(0.176)	1.249	(0.184)	0.765	(0.138)	0.577	(0.161)
334210	1.546	(0.147)	1.209	(0.078)	1.578	(0.157)	1.583	(0.138)	1.207	(0.138)	1.525	(0.561)
334220	1.128	(0.070)	1.018	(0.017)	1.117	(0.067)	1.113	(0.084)	0.848	(0.090)	0.586	(0.144)
334290	1.228	(0.049)	1.046	(0.015)	1.197	(0.036)	1.190	(0.042)	0.972	(0.041)	0.904	(0.124)
334310	1.048	(0.084)	1.003	(0.010)	1.031	(0.055)	1.057	(0.057)	0.925	(0.047)	0.727	(0.127)
334411	1.160	(0.078)	1.044	(0.031)	1.157	(0.056)	1.156	(0.064)	1.032	(0.044)	1.103	(0.189)
334412	1.332	(0.051)	1.131	(0.033)	1.316	(0.066)	1.208	(0.084)	1.023	(0.060)	1.055	(0.161)
334413	1.779	(0.328)	1.241	(0.120)	1.477	(0.149)	1.505	(0.148)	1.346	(0.202)	2.951	(3.951)
334414	1.269	(0.050)	1.075	(0.023)	1.209	(0.047)	1.246	(0.043)	0.995	(0.046)	0.990	(0.096)
334415	1.435	(0.109)	1.165	(0.055)	1.384	(0.081)	1.392	(0.083)	1.144	(0.134)	1.354	(0.529)
334416	1.414	(0.064)	1.172	(0.037)	1.405	(0.060)	1.404	(0.056)	1.047	(0.180)	1.075	(0.323)
334417	1.565	(0.198)	1.201	(0.096)	1.353	(0.125)	1.301	(0.171)	1.298	(0.122)		
334418	1.160	(0.031)	1.030	(0.010)	1.143	(0.027)	1.132	(0.038)	0.946	(0.040)	0.821	(0.099)
334419	1.076	(0.103)	1.006	(0.016)	1.051	(0.076)	1.093	(0.051)	0.922	(0.042)	0.735	(0.102)
334510	1.196	(0.262)	1.036	(0.075)	1.182	(0.207)	1.194	(0.155)	0.797	(0.368)	0.591	(0.377)
334511	1.073	(0.077)	1.006	(0.012)	1.069	(0.071)	1.107	(0.086)	0.697	(0.151)	0.453	(0.102)
334512	1.265	(0.064)	1.079	(0.026)	1.245	(0.049)	1.231	(0.040)	0.777	(0.070)	0.723	(0.047)
334513	1.277	(0.129)	1.056	(0.042)	1.199	(0.096)	1.191	(0.070)	0.812	(0.095)	0.635	(0.104)
334514	1.317	(0.141)	1.096	(0.068)	1.264	(0.130)	1.394	(0.117)	0.780	(0.113)	0.769	(0.080)
334515	1.426	(0.090)	1.124	(0.044)	1.374	(0.101)	1.401	(0.114)	0.868	(0.091)	0.779	(0.118)
334516	1.507	(0.058)	1.146	(0.021)	1.423	(0.034)	1.431	(0.045)	1.473	(0.310)		
334517	1.591	(0.285)	1.155	(0.101)	1.339	(0.148)	1.421	(0.172)	1.123	(0.159)	1.350	(0.660)
334518	1.532	(0.089)	1.188	(0.041)	1.393	(0.058)	1.419	(0.189)	1.179	(0.052)	1.492	(0.407)
334519	1.242	(0.164)	1.038	(0.044)	1.135	(0.095)	1.065	(0.115)	0.734	(0.158)	0.507	(0.131)
334612	1.209	(0.112)	1.075	(0.062)	1.236	(0.133)	1.285	(0.152)	1.004	(0.108)	1.006	(0.176)
334613	1.042	(0.103)	1.002	(0.011)	1.027	(0.062)	0.926	(0.057)	0.937	(0.057)	3.231	(17.274)
335110	1.408	(0.122)	1.245	(0.091)	1.451	(0.124)	1.425	(0.065)	0.914	(0.160)		
335121	1.320	(0.121)	1.116	(0.070)	1.306	(0.141)	1.297	(0.133)	1.061	(0.060)	1.136	(0.181)
335122	1.352	(0.117)	1.116	(0.056)	1.282	(0.091)	1.238	(0.060)	1.113	(0.047)	1.477	(0.428)
335129	1.324	(0.108)	1.111	(0.053)	1.305	(0.094)	1.291	(0.107)	0.965	(0.178)	0.939	(0.279)
335211	1.217	(0.096)	1.085	(0.054)	1.280	(0.115)	1.244	(0.081)	0.745	(0.159)		
335212	1.207	(0.049)	1.066	(0.024)	1.207	(0.052)	1.208	(0.044)	0.946	(0.055)	0.907	(0.075)
335221	0.947	(0.108)	1.008	(0.034)	0.960	(0.069)	0.995	(0.063)	0.792	(0.032)	0.680	(0.079)
335222	0.898	(0.278)	1.035	(0.192)	0.949	(0.097)	0.967	(0.074)	0.903	(0.080)	0.671	(0.382)
335224	1.236	(0.090)	1.111	(0.059)	1.260	(0.093)	1.267	(0.086)	0.805	(0.139)		
335228	1.161	(0.076)	1.055	(0.039)	1.170	(0.072)	1.169	(0.070)	0.964	(0.130)	0.942	(0.176)

Continued on next page

Table TA2 – continued from previous page

NAICS	Benchmark						Alternative					
	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
335311	1.386	(0.095)	1.154	(0.056)	1.343	(0.090)	1.306	(0.095)	1.063	(0.086)	1.125	(0.221)
335312	1.337	(0.028)	1.128	(0.016)	1.287	(0.037)	1.346	(0.034)	1.045	(0.037)	1.070	(0.067)
335313	1.397	(0.140)	1.093	(0.058)	1.180	(0.089)	1.323	(0.100)	1.081	(0.068)	1.186	(0.218)
335314	1.439	(0.033)	1.142	(0.015)	1.374	(0.041)	1.396	(0.031)	0.989	(0.059)	0.979	(0.106)
335911	1.078	(0.102)	1.016	(0.037)	1.076	(0.102)	1.106	(0.095)	0.668	(0.126)		
335912	0.965	(0.212)	1.003	(0.042)	0.974	(0.155)	0.949	(0.144)	0.768	(0.121)	0.614	(0.257)
335921	1.098	(0.128)	1.016	(0.039)	1.074	(0.112)	1.181	(0.133)	0.878	(0.047)	0.832	(0.067)
335929	0.345	(5.239)	3.394	(199.773)	0.907	(0.099)	0.984	(0.054)	0.871	(0.040)	0.612	(0.165)
335931	1.457	(0.063)	1.178	(0.033)	1.378	(0.057)	1.425	(0.061)	1.105	(0.066)	1.192	(0.162)
335932	1.401	(0.074)	1.160	(0.036)	1.357	(0.043)	1.353	(0.058)	1.024	(0.102)	1.038	(0.174)
335991	1.640	(0.344)	1.235	(0.157)	1.321	(0.149)	1.527	(0.208)	1.247	(0.174)	1.454	(0.661)
335999	1.240	(0.059)	1.054	(0.022)	1.203	(0.051)	1.225	(0.076)	0.812	(0.062)	0.686	(0.068)
336111	1.249	(0.044)	1.120	(0.033)	1.225	(0.054)	1.250	(0.043)	1.130	(0.052)	1.266	(0.238)
336112	0.053	(3.560)	0.153	(9.188)	1.083	(0.029)	1.242	(0.029)	1.132	(0.025)	1.273	(0.129)
336120	1.155	(0.033)	1.051	(0.015)	1.129	(0.027)	1.173	(0.031)	1.03	(0.031)	1.057	(0.073)
336211	1.311	(0.166)	1.072	(0.060)	1.120	(0.091)	1.174	(0.074)	1.095	(0.059)	1.427	(0.689)
336212	1.220	(0.030)	1.089	(0.020)	1.240	(0.059)	1.222	(0.042)	1.024	(0.032)	1.043	(0.064)
336213	1.211	(0.026)	1.067	(0.014)	1.188	(0.030)	1.194	(0.032)	1.113	(0.030)	1.560	(0.413)
336214	1.246	(0.029)	1.087	(0.019)	1.213	(0.045)	1.235	(0.042)	1.124	(0.043)	1.434	(0.351)
336311	1.599	(0.108)	1.243	(0.066)	1.285	(0.074)	1.384	(0.062)	1.253	(0.073)	1.704	(0.668)
336312	1.300	(0.209)	1.075	(0.045)	1.104	(0.095)	1.226	(0.056)	1.084	(0.058)	1.174	(0.199)
336321	1.153	(0.089)	1.027	(0.026)	1.081	(0.049)	1.173	(0.070)	0.968	(0.076)	0.939	(0.125)
336322	1.315	(0.081)	1.109	(0.043)	1.222	(0.068)	1.324	(0.053)	1.075	(0.067)	1.129	(0.150)
336330	1.281	(0.026)	1.126	(0.025)	1.263	(0.076)	1.287	(0.019)	1.094	(0.058)	1.157	(0.145)
336340	1.306	(0.061)	1.128	(0.028)	1.242	(0.030)	1.297	(0.028)	1.123	(0.063)	1.237	(0.210)
336350	1.277	(0.057)	1.110	(0.030)	1.193	(0.045)	1.257	(0.042)	1.122	(0.039)	1.261	(0.173)
336360	1.122	(0.058)	1.031	(0.023)	1.120	(0.051)	1.120	(0.057)	0.992	(0.064)	0.978	(0.163)
336370	1.494	(0.093)	1.275	(0.064)	1.428	(0.075)	1.453	(0.073)	1.344	(0.089)	2.046	(1.295)
336391	1.326	(0.111)	1.106	(0.059)	1.213	(0.086)	1.261	(0.059)	1.103	(0.088)	1.274	(0.396)
336399	1.377	(0.033)	1.170	(0.019)	1.295	(0.049)	1.330	(0.037)	1.188	(0.026)	1.464	(0.184)
336411	1.018	(0.064)	1.001	(0.004)	1.017	(0.059)	1.029	(0.053)	0.713	(0.059)	0.486	(0.061)
336412	1.435	(0.088)	1.148	(0.039)	1.382	(0.061)	1.39	(0.053)	1.085	(0.109)	1.199	(0.327)
336413	1.019	(0.051)	1.001	(0.004)	1.019	(0.051)	1.021	(0.046)	0.697	(0.042)	0.538	(0.045)
336414	1.060	(0.040)	1.005	(0.006)	1.062	(0.043)	1.065	(0.053)	0.659	(0.101)	0.355	(0.060)
336415	1.236	(0.111)	1.058	(0.045)	1.273	(0.134)	1.185	(0.057)	0.376	(0.154)		
336419	1.678	(0.101)	1.271	(0.050)	1.637	(0.079)	1.504	(0.049)	1.018	(0.136)	1.032	(0.249)
336510	1.219	(0.088)	1.065	(0.049)	1.184	(0.106)	1.236	(0.054)	0.972	(0.046)	0.953	(0.070)
336611	1.114	(0.100)	1.032	(0.043)	1.136	(0.106)	1.101	(0.118)	0.759	(0.201)	0.752	(0.084)
336612	1.295	(0.070)	1.105	(0.039)	1.198	(0.067)	1.240	(0.062)	1.138	(0.059)	1.463	(0.533)

Continued on next page

Table TA2 – continued from previous page

	Benchmark						Alternative					
NAICS	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)	γ	(s.e.)	γ_y	(s.e.)	α	(s.e.)
336991	1.276	(0.090)	1.111	(0.048)	1.261	(0.064)	1.262	(0.073)	1.044	(0.093)	1.078	(0.198)
336992	1.188	(0.035)	1.043	(0.015)	1.150	(0.043)	1.231	(0.030)	1.022	(0.039)	1.054	(0.107)
336999	1.164	(0.075)	1.031	(0.030)	1.106	(0.075)	1.169	(0.055)	0.980	(0.039)	0.952	(0.084)
337110	1.373	(0.034)	1.156	(0.016)	1.281	(0.032)	1.307	(0.029)	1.226	(0.038)	2.035	(0.743)
337121	1.252	(0.060)	1.120	(0.035)	1.283	(0.046)	1.283	(0.051)	0.989	(0.168)	0.988	(0.177)
337122	1.619	(0.068)	1.317	(0.047)	1.403	(0.100)	1.449	(0.069)	1.368	(0.088)	2.558	(2.410)
337124	1.219	(0.037)	1.081	(0.021)	1.235	(0.045)	1.232	(0.053)	1.042	(0.095)	1.089	(0.249)
337125	1.196	(0.049)	1.078	(0.027)	1.240	(0.050)	1.228	(0.037)	1.124	(0.047)	1.449	(0.399)
337127	1.118	(0.108)	1.032	(0.046)	1.156	(0.130)	1.168	(0.134)	1.050	(0.148)	1.185	(0.801)
337129	1.278	(0.113)	1.121	(0.077)	1.255	(0.126)	1.265	(0.122)	1.159	(0.108)	1.492	(0.986)
337211	1.404	(0.086)	1.192	(0.057)	1.412	(0.092)	1.417	(0.065)	1.157	(0.116)	1.278	(0.334)
337212	1.436	(0.091)	1.193	(0.053)	1.400	(0.084)	1.391	(0.080)	1.328	(0.083)	3.540	(5.038)
337214	1.514	(0.065)	1.235	(0.042)	1.457	(0.073)	1.469	(0.075)	1.135	(0.036)	1.213	(0.089)
337215	1.341	(0.049)	1.135	(0.027)	1.307	(0.048)	1.321	(0.044)	1.187	(0.054)	1.645	(0.481)
337910	1.321	(0.116)	1.112	(0.060)	1.269	(0.113)	1.285	(0.089)	1.091	(0.101)	1.230	(0.387)
337920	1.369	(0.046)	1.103	(0.023)	1.215	(0.040)	1.250	(0.048)	1.069	(0.035)	1.194	(0.141)
339111	1.427	(0.104)	1.140	(0.044)	1.398	(0.073)	1.431	(0.067)	1.030	(0.234)	1.062	(0.512)
339112	1.344	(0.213)	1.097	(0.090)	1.281	(0.168)	1.290	(0.133)	0.827	(0.145)	0.743	(0.143)
339113	1.286	(0.105)	1.083	(0.046)	1.283	(0.097)	1.359	(0.066)	0.509	(0.126)		
339114	1.438	(0.253)	1.134	(0.110)	1.328	(0.175)	1.241	(0.185)	1.018	(0.223)	1.051	(0.692)
339115	1.121	(0.142)	1.020	(0.041)	1.096	(0.113)	1.157	(0.124)	0.614	(0.065)		
339911	1.205	(0.084)	1.065	(0.034)	1.244	(0.066)	1.253	(0.067)	1.052	(0.108)	1.143	(0.374)
339912	1.243	(0.084)	1.081	(0.043)	1.231	(0.085)	1.246	(0.091)	1.026	(0.085)	1.054	(0.200)
339913	0.998	(0.034)	1.000	(0.000)	0.998	(0.036)	1.011	(0.038)	0.868	(0.046)	0.618	(0.089)
339914	1.273	(0.060)	1.087	(0.028)	1.251	(0.053)	1.249	(0.079)	0.871	(0.083)	0.820	(0.080)
339920	1.299	(0.134)	1.112	(0.067)	1.318	(0.112)	1.298	(0.084)	1.025	(0.123)	1.049	(0.261)
339931	1.566	(0.115)	1.271	(0.072)	1.590	(0.119)	1.624	(0.139)	0.843	(0.148)		
339932	1.393	(0.091)	1.161	(0.052)	1.410	(0.095)	1.428	(0.100)	1.156	(0.094)	1.346	(0.345)
339941	1.345	(0.086)	1.140	(0.047)	1.375	(0.079)	1.354	(0.097)	0.829	(0.112)	0.820	(0.082)
339942	1.033	(0.110)	1.002	(0.014)	1.033	(0.110)	1.080	(0.064)	0.455	(0.115)		
339943	1.410	(0.121)	1.142	(0.053)	1.345	(0.076)	1.381	(0.072)	0.999	(0.129)	0.999	(0.216)
339944	1.082	(0.041)	1.012	(0.010)	1.078	(0.038)	1.087	(0.036)	0.782	(0.084)	0.657	(0.047)
339950	1.286	(0.117)	1.093	(0.053)	1.278	(0.093)	1.256	(0.103)	1.047	(0.137)	1.126	(0.452)
339991	1.704	(0.052)	1.336	(0.035)	1.606	(0.059)	1.633	(0.038)	1.251	(0.060)	1.417	(0.168)
339992	1.176	(0.043)	1.038	(0.020)	1.104	(0.044)	1.172	(0.085)	1.002	(0.068)	1.005	(0.151)
339993	1.168	(0.091)	1.049	(0.038)	1.177	(0.074)	1.163	(0.064)	0.980	(0.130)	0.954	(0.272)
339994	1.090	(0.202)	1.015	(0.059)	1.081	(0.181)	1.130	(0.173)	0.747	(0.186)	0.717	(0.110)
339995	0.968	(0.204)	1.003	(0.039)	0.973	(0.170)	0.960	(0.174)	0.765	(0.150)	0.619	(0.275)
339999	1.444	(0.065)	1.175	(0.031)	1.386	(0.051)	1.399	(0.079)	1.169	(0.077)	1.422	(0.356)