ANNALS OF ECONOMICS AND FINANCE **19-2**, 683–701 (2018)

China's New Silk Road and China-EU Trade

Chu Ping Lo*

This paper develops a simple model, wherein firms choose to pay a premium for timely delivered freight since consumers place more value on goods that arrive sooner than later, to estimate the impact of China's "New Silk Road" (NSR) initiative on trade between China and Europe. We argue that if China's NSR is sufficiently realized, many time-sensitive firms that currently use maritime transport might switch to ground transport as the latter shortens transit time sharply at reasonable costs, hereby enlarging the market demands. Consequently, NSR might, ceteris paribus, increase trade between China and Europe by an additional 8% to 32%.

Key Words: One Belt One Road, New Silk Road, China, Europe.
JEL Classification Numbers: F11, F17.

1. INTRODUCTION

China launched its One Belt One Road (OBOR) initiative in 2013 so as to regain its role as a major player in the once the world's largest regional collaboration platform. The OBOR consists of two main components, the land-based "New Silk Road Economic Belt" and the ocean-going "21st Century Maritime Silk Road", covering about 65 percent of the world's population and about one-third of the world's GDP. The land-based one links China with Europe through Central and Western Asia, while the ocean-going route connects China with Southern Asian countries, Africa, and Europe. The OBOR initiative is a development strategy that aims to improve cross-border infrastructure in order to reduce transportation costs across a massive geographical area between China and Europe (e.g., Herrero and Wu, 2016). Nevertheless, it places more emphasis on connectivity and cooperation by the land-based "New Silk Road Economic Belt" in Eurasia, calling for massive infrastructure investment in the region's land-trade routes. These land-trade routes are more reliable transit links that

*Department of Agricultural Economics, National Taiwan University, Taipei, Taiwan. Email: cplo@ntu.edu.tw. The financial support provided by Taiwan's Ministry of Science and Technology (106-2410-H-002-013-) is gratefully acknowledged.

1529-7373/2018

have advantages of lower transport costs and faster freight times, thus creating more new trade opportunities. In this paper, we focus on China's "New Silk Road Economic Belt" and address how much it might increase trade between China and Europe.

As is widely known, Central Asia and Western Asia both possess significant physical barriers to extra-regional trade in nearly all directions, such as high plateaus, deserts, and soaring mountains. Thus, maritime transport has dominated the international trade transportation between Asia and Europe ever since the Industrial Revolution. To reduce those physical barriers hindering ground transport, China, which is endowed with advanced railway technology and excess capacity, recently pledged US$ 40 billion to a Silk Road Fund designed to improve transport infrastructure in Eurasia. With a similar purpose to support the building of (transportation) infrastructure in this trade bloc, China has also launched the Asian Infrastructure Investment Bank (AIIB) and whose initial capital is US$ 100 billion.[1]

The progress of the "New Silk Road Economic Belt" is quite amazing. For example, there are nine railway lines connecting Europe and China in 2015 (Li, et al, 2016). Till 2017, the China-Europe Railway Express has already grown to 51 rail links connecting 27 Chinese and 28 European cities, with freight trains that offer shorter transport time than sea routes.[2] When the New Silk Road (NSR) makes ground transport a cost-efficient way to carry out trade between China and Europe, some firms that formerly use either air transport or maritime transport might switch to ground transport. The consequential reduction in transportation cost, in particular due to the development on ground transport infrastructure, should stimulate more trade within the Eurasia bloc.[3] A question arises: How much trade might be created if the New Silk Road makes ground transport the prevalent mode of transport between China and Europe? This paper aims to present a simple model of trade with heterogeneous firms and variations in industry characteristics to address this issue and to estimate the impacts.

In this paper, we incorporate consumer preferences that value timely delivery, as suggested in the literature (e.g., Hummels and Schaur, 2013), into the trade model with heterogeneous firms as in Eaton and Kortum (2002), Chaney (2008), and Arkolakis (2010). Similar to Hummels and Schaur

[1]AIIB opened for business in January 2016. Fifty-seven Asian countries, especially Central Asian countries that are in need of infrastructure development, are the Founding Members.

[2]Source: THE STREET TIMES (2017/5/24).

[3]Through a simulation, Herrero and Wu (2016) find that a 10 percent reduction in railway, air and maritime costs increases trade by 2 percent, 5.5 percent and 1.1 percent respectively. However, in this current paper, we aim to provide a theoretical model to predict and focus on how much the reduction in ground transport cost alone in fostering trade between China and Europe.

(2013), firms with different productivity levels choose different transport modes, based on sectoral characteristics regarding timely delivery. That is, to satisfy consumer preferences on timely delivery in potential markets, firms choose among three modes of international shipment (i.e., ground, sea, and air), and the choice depends on a tradeoff between the corresponding freight costs and the value attached to timely delivery.

In Hummels and Schaur's (2013) framework, a firm with a specific productivity chooses its optimal transport mode by comparing the profitability of air versus ocean shipping. However, in contrast, we formalize the firm heterogeneity by assuming that firm productivity follows a distribution as in Eaton and Kortum (2002), Chaney (2008), and Arkolakis (2010). By this way, this current model has the advantage that it can specify total trade volume in different transport modes and then provide a quantitative framework to estimate the impact of shifting between the transport modes on trade in aggregate.

The paper helps explain why ground (e.g., rail) transport is optimally suited for hauling high-value industrial products like vehicles, electronics, and equipment that are usually somehow sensitive to timely delivery (e.g., Li, et al, 2016). Most important, this paper provides a theoretical foundation to suggest that if China's land-based "New Silk Road Economic Belt" is sufficiently realized, it could enlarge market demands due to the fact that consumers place more value on goods that arrive sooner than later. As a result, China's NSR might, ceteris paribus, increase trade between China and Europe by an additional 8% to 32%. However, to focus on our analysis, in this paper, we only consider the impact of an improvement of the ground transportation infrastructure on trade between China and Europe, and neglects other important components of the NSR initiative, such as tariff reduction, improvement in maritime infrastructure, and political issues.[4]

In the remainder of this paper, Section 2 illustrates the model, and equilibrium is presented in Section 3. Section 4 discusses the choices of transport modes under different circumstances. Concluding remarks are in Section 5.

[4]It has been reported that currently the One Belt, One Road has made trains loaded with Chinese goods trundling towards Europe laden but returning empty, which instead has led to the quip "One Belt, One Way" Some have also concerned that the genuine infrastructure needs and commercial logic might be secondary to political motivations for the NSR, leading to a heightened risk of projects proving unprofitable (France-Presse, 2017).

2. THE MODEL

Firms have choices of paying premium freight costs to shorten the transit times of delivering their goods, while consumers place more value on goods that arrive sooner rather than later (e.g., Hummels and Klenow, 2005; Hallak, 2006; Hallak and Schott, 2011 and Hummels and Schaur, 2013). Therefore, it is an endogenous choice for exporting firms of whether to pay a premium for timely delivery.

Consumers in each country derive utility from the consumption of a continuum of goods indexed by ω, according to a symmetric constant elasticity of substitution (CES) utility function:

$$U_j = \left[\sum_{i=1}^{N} \int_{\omega \in \Omega} \int_0^1 q_{ij}(\omega, z)^{(\sigma-1)/\sigma} dz d\omega \right]^{\sigma/(\sigma-1)},$$

where Ω is a potential set of all the goods sold in country j and $\sigma > 1$ is the elasticity of substitution. Here, $q_{ij}(\omega)$ is country j's consumption of the imported goods from country i. The industry parameter $1 > z > 0$ measures how a good is sensitive to timely delivery; the larger z is, the more the good is sensitive to timely delivery.

2.1. Demand Function with Transit Time

A firm i draws its productivity from a Pareto distribution with a country-specific positive level parameter b_i as $G_i(\phi) = 1 - b_i^\theta / \phi^\theta$ (e.g., Melitz, 2003; Eaton and Kortum, 2002) and $b_i \leq \phi$ is an exogenous constant.[5] Following Hummels and Schaur (2013), demand for the good produced by a firm with productivity ϕ from country i charging a price $p_{ij}(\phi)$ in country j is

$$q_{ij}^m(\phi) = (p_{ij}(\phi) e^{z\gamma d_{ij}^m})^{-\sigma} P_j^{\sigma-1} w_j L_j, \qquad (1)$$

where w_j is per capita income in country j, $\sigma > 1$ is the constant elasticity of substitution parameter, L_j is a given measure of identical consumers in the destination country j, and P_j is aggregate price in country j. Each consumer $l \in [0, L_j]$ accesses a potential set of goods Ω_j. Here, the aggregate price P_j is defined as

$$P_j^{1-\sigma} = \int_{\omega \in \Omega_j} \int_0^1 p_{ij}(\omega, z)^{1-\sigma} dz d\omega.$$

In equation (1), the variable d_{ij}^m represents the days in transit by transport modes $m \in \{a, g, s\}$, where a denotes air shipment, g denotes ground

[5]As in Arkolakis (2010), we assume $b_i \leq \min_j \phi_{ij}^*$ to ensure a positive distribution of sales for firms, where ϕ_{ij}^* is the productivity threshold that we will discuss later.

shipment and s denotes ocean shipment. The parameter γ, as suggested in Hummels and Schaur (2013), translates days of delay into a price equivalent form, and the elasticity of substitution parameter σ translates this into the quantity of lost sales. Nevertheless, the impacts of transit times on demand is depending on its sensitivity to timely delivery. Equation (1) implies that a delay in delivery might weaken consumers' wishes, such that a one-day reduction in delivery times raises demand by $z\gamma\sigma$ percent. The reasons why lengthy shipment times lead to a shrinking demand are either related to the goods being spoiled (e.g., agricultural products) or their rapid technological obsolescence (e.g., consumer electronics), among other reasons (e.g., Aizenman, 2004; Evans and Harrigan, 2005; Harrigan and Venables, 2006; and Hummels and Schaur, 2013).

2.2. Trade Costs in Different Transport Modes

Trade costs in general not only take an ad valorem form (e.g., tariffs), but also a non-ad-valorem form (e.g., freight costs). Let $\tau_{ij} \geq 1$ denote the ad-valorem type of trade cost, and which is the traditional iceberg trade cost as $\tau_{ii} = 1$ and $\tau_{ij} \geq 1$ for a pairs of countries i, j. With the CES utility function in monopolistic competition, we obtain the delivered price as

$$p_{ij}(\phi) = \frac{\sigma}{\sigma - 1}\left(\frac{w_i}{\phi}\tau_{ij}\right), \tag{2}$$

where $\sigma/(\sigma - 1)$ is the mark up over the good's marginal cost.

It has been suggested by recent literature that the delivery time it takes for goods to be exported is a better proxy for transport costs than is the distance in transit, especially for time-sensitive goods (e.g., Hummels, 2007; Hummels and Schaur, 2013; Djankov et al, 2010). In particular, Djankov et al. (2010) argue that each additional day that a product is delayed prior to being shipped reduces trade by more than 1%.

In order to reduce delivery times, a firm could consider paying a premium for timely delivery when time is an important factor for satisfying market demands. We therefore argue that, given a shipping distance, the non-ad-valorem form of trade costs increases with the premium that a firm is willing to pay for timely delivery as

$$F_{ij}^m = w_i f_{ij}^m(d_{ij}^m), \tag{3}$$

where w_i is the wage cost in the country of origin and f_{ij}^m represents freight costs in transport mode m. The freight costs increase with the transit time for all modes as $f_{ij}^{m'}(d_{ij}^m) > 0$, $\forall m$. Nevertheless, in real practice, air shipping takes the least amount of time while ocean shipping takes the longest. Thus, air cargo services charge the highest freight premium, followed by ground, and then by sea, such that we have $F_{ij}^a > F_{ij}^g > F_{ij}^s$ for a pairs of countries i, j.

3. EQUILIBRIUM

With equation (2), we can rewrite the demand in equation (1) as

$$q_{ij}^m(\phi) = e^{-\sigma z \gamma d_{ij}^m} \left(\frac{\sigma}{\sigma - 1} \frac{w_i}{\phi} \tau_{ij} \right)^{-\sigma} P_j^{\sigma-1} w_j L_j.$$

By combining the demand function above with price in equation (2), the market in country j for a firm with productivity ϕ becomes

$$x_{ij}^m(\phi, z) = \overline{\sigma} e^{-d_{ij}^m \sigma \gamma z} \left(\frac{w_i}{\phi} \tau_{ij} \right)^{1-\sigma} A_j, \tag{4}$$

where $x_{ij}^m(\phi) = p_{ij}(\phi) q_{ij}^m(\phi)$, $\overline{\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}$ and $A_j \equiv P_j^{\sigma-1} w_j L_j$. The total profit of this firm in country j is then

$$\pi_{ij}^m(\phi, z) = A_{ij} e^{-d_{ij}^m \sigma \gamma z} \phi^{\sigma-1} - w_i f_{ij}^m, \tag{5}$$

where $A_{ij} \equiv A_j \frac{\overline{\sigma}}{\sigma} (w_i \tau_{ij})^{1-\sigma}$. Free entry leads to $\pi_{ij}^m(\phi_{ij}^{m^*}) = 0$, where $\phi_{ij}^{m^*}$ denotes the productivity threshold for the least productive firms, which are completely insensitive to timely delivery, from country i that are able to access market j:

$$\phi_{ij}^{m^*} = e^{\frac{d_{ij}^m \sigma \gamma z}{\sigma - 1}} \left(\frac{\sigma}{\overline{\sigma}} \frac{w_i f_{ij}^m}{A_j} \right)^{\frac{1}{\sigma-1}} w_i \tau_{ij}.^6 \tag{6}$$

Equilibrium Conditions

We presume that all modes of firms follow the same Pareto distribution. Total number of firms originating from country i is defined as $M_i = \sum_j \sum_m M_{ij}^m$, where $M_{ij}^m = M_i (b_i / \phi_{ij}^{m^*})^\theta$ denotes the total number of firms originating from country i that export to country j by transport mode m.[7]

[6] Note that $\phi_{ij}^{m^*}(z) = e^{\frac{d_{ij}^m \sigma \gamma z}{\sigma-1}} \left(\frac{\sigma}{\overline{\sigma}} \frac{w_i f_{ij}^m}{A_j} \right)^{\frac{1}{\sigma-1}} w_i \tau_{ij} \leq \phi_{ij}^{m^*}(z = 0)$, $\forall z$.

[7] Consider a market j that is divided into three sub-markets: j^a, j^g, and j^s. Here, M_{ij}^a is the number of firms from i that export to the sub-market j^a, M_{ij}^g is the number of firms from i that export to the sub-market j^g, and M_{ij}^s is the number of firms from i that export to the sub-market j^s. In total, $M_{ij} = \sum_m M_{ij}^m$ is total number of firms from country i that export to country j.

Suppose each firm in country i incurs an entry cost f_i^e to access markets. The expected profit of a firm must be equal to the entry costs, and hence we have an equilibrium:

$$\sum_m \sum_j \int_0^1 \int_0^\infty \left[A_j \frac{\overline{\sigma}}{\sigma} e^{-d_{ij}^m \sigma \gamma z} \left(\frac{w_i}{\phi} \tau_{ij} \right)^{1-\sigma} - f_{ij}^m \right] dG_i(\phi) dz = w_i f_i^e.$$

Trade flows from country i that serve country j under transport mode m are

$$X_{ij}^m = M_i \int_0^1 \int_{\phi_{ij}^{m*}}^\infty x_{ij}^m(\phi, z) dG_i(\phi) dz. \tag{7}$$

Trade balance requires that

$$\sum_j \sum_m X_{ij}^m = w_i L_i,$$

where L_i also denotes total labor supply in country i.

Gravity Model

With (6) and (7), the trade flow of transport mode m from country i to j is

$$X_{ij}^m = \frac{\sigma\theta}{\theta - (\sigma - 1)} M_{ij}^m w_i f_{ij}^m \frac{1 - e^{-\sigma\gamma d_{ij}^m}}{\sigma\gamma d_{ij}^m}.^{8} \tag{8}$$

The total trade flow from country i to j is then given by

$$X_{ij} = \frac{\sigma\theta}{\theta - (\sigma - 1)} \sum_m M_{ij}^m w_i f_{ij}^m \frac{1 - e^{-\sigma\gamma d_{ij}^m}}{\sigma\gamma d_{ij}^m}. \tag{9}$$

With (8), the average sales of transport mode m from country i to j are

$$\frac{X_{ij}^m}{M_{ij}^m} = \frac{\sigma\theta}{\theta - (\sigma - 1)} w_i f_{ij}^m \frac{1 - e^{-\sigma\gamma d_{ij}^m}}{\sigma\gamma d_{ij}^m}. \tag{10}$$

In line with the literature (e.g., Chaney, 2008; Eaton, Kortum, and Kramarz, 2011; Arkolakis, 2010), the average sales in (10) rise with the exogenous trade costs. However, the average sales fall with transit times to

[8]The (8) can be rewritten as $X_{ij}^m = \int_0^1 M_i^m \overline{\sigma} e^{-\sigma\gamma z d_{ij}^m} (w_i \tau_{ij})^{1-\sigma} A_j b_i^\theta \frac{\theta}{\theta-(\sigma-1)} \phi_{ij}^{m*\,\sigma-\theta-1} dz$. After some calculation, we obtain $X_{ij}^m = \int_0^1 M_{ij}^m \frac{\sigma\theta}{\theta-(\sigma-1)} w_i f_{ij}^m e^{-\sigma\gamma z d_{ij}^m} dz = \frac{\sigma\theta}{\theta-(\sigma-1)} M_{ij}^m w_i f_{ij}^m w_i f_{ij}^m \frac{1-e^{-\sigma\gamma d_{ij}^m}}{\sigma\gamma d_{ij}^m}$.

the market (i.e., d_{ij}^m),[9] reflecting the fact that people place more value on timely-delivered goods.

4. CHOICES OF TRANSPORT MODES

For firms engaged in trade, there is a tradeoff between delivery time and delivery costs. Ground transport is typically more affordable, but slower than air on one hand, and more expensive but faster than by sea on the other hand. For those occasions when ground transport is not an option, firms choose either fast but expensive air transport or slow but cheaper sea transport. However, once ground transport is available, some firms that formerly used either air or sea transports might switch to ground transport.

In order to illustrate this tradeoff, we classify the sensitiveness of industries regarding to timely delivery into three cases, i.e., highly sensitive, mildly sensitive, and insensitive, assigning two arbitrarily cutoff sensitivity $\overline{z}$ and $\underline{z}$ as the critical points, where $1 > \overline{z} > \underline{z} > 0$.

Case 1: Less Sensitive to Timely Delivery ($\underline{z} > z > 0$).

When an industry is less sensitive to timely delivery as $\underline{z} > z > 0$, a small z implies that the cutoff productivities in each mode have the ordering of $\phi_{ij}^a(z) > \phi_{ij}^g(z) > \phi_{ij}^s(z)$. The delivery times of each mode have the ordering of $d_{ij}^s > d_{ij}^g > d_{ij}^a$, while the freight costs have the ordering of $f_{ij}^s < f_{ij}^g < f_{ij}^a$. As a result, we can illustrate the profit functions in (5) with respect to productivity as in Figure 1. As shown by the bold lines in Figure 1, when an industry z is less sensitive to timely delivery, the most productive firms prefer air transport, the less productive firms prefer ground transport, and the even less productive firms prefer sea transport.[10]

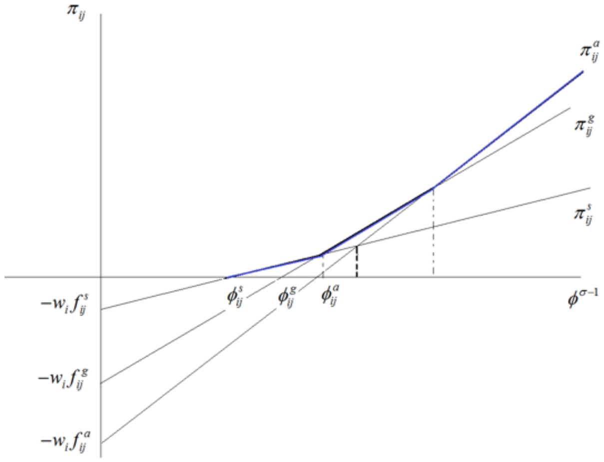
Note that when ground transport is not an option, as shown by the thin lines in Figure 1, when an industry z is less sensitive to timely delivery, the relatively high productive firms prefer air transport, and the relatively less productive firms prefer sea transport. To the contrary, when ground transport is available, time-insensitive firms (especially relatively low productivity firms) will still employ the maritime transport, while some relatively high productive firms might turn to ground transport.

---

[9]Taking a derivative of $\frac{1-e^{-\sigma\gamma d_{ij}^m}}{\sigma\gamma d_{ij}^m}$ in (10) with respect to d_{ij}^m, we get $\frac{e^{-\sigma\gamma d_{ij}^m}(1+\sigma\gamma d_{ij}^m)-1}{\sigma\gamma {d_{ij}^m}^2} \cong -\sigma\gamma < 0$, implying that consumers favor timely delivery. To the contrary, for firms' point of view of, the freight costs in (3) increases with the transit time as $f_{ij}^{m'}(d_{ij}^m) > 0$, $\forall m$, implying that the average sales in (10) increases with transit time d_{ij}^m.

[10]With $d_{ij}^s > d_{ij}^g > d_{ij}^a$, the slopes of the profit function in (5) have the ordering of $A_{ij}e^{-d_{ij}^a\sigma\gamma z} > A_{ij}e^{-d_{ij}^g\sigma\gamma z} > A_{ij}e^{-d_{ij}^s\sigma\gamma z}$.

FIG. 1. When industries are less sensitive to timely delivery[11]



Case 2: Mildly Sensitive to Timely Delivery ($\overline{z} > z > \underline{z}$).

When an industry is mildly sensitive to timely delivery as $\overline{z} > z > \underline{z}$, a relatively small z implies that the cutoff productivities in each mode have the ordering of $\phi^a_{ij}(z) > \phi^g_{ij}(z)$ but $\phi^s_{ij}(z) > \phi^g_{ij}(z)$. Again, with $d^s_{ij} > d^g_{ij} > d^a_{ij}$ and $f^s_{ij} < f^g_{ij} < f^a_{ij}$, we can illustrate the profit functions in (5) in Figure 2.[12] As illustrated by the bold lines in Figure 2, when an industry is mildly sensitive to timely delivery, the most productive firms prefer to export by air transport, the less productive firms prefer to export by ground transport, and no firms choose sea transport.

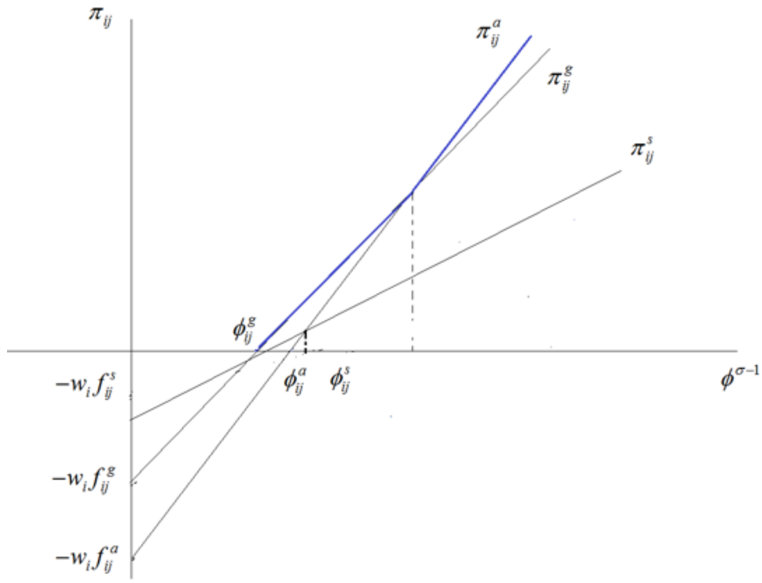
In Figure 2, when industries are mildly sensitive to timely delivery, almost all the relatively low productivity firms turn to ground transport, especially switching away from sea transport. Figure 2 also implies that ground transport helps reduce the productivity threshold to trade, and a lower the productivity threshold thereby encourages some formerly non-exporting firms to export.[13]

Case 3: Highly Sensitive to Timely Delivery ($1 > z > \overline{z}$).

When an industry is highly sensitive to timely delivery (i.e., $1 > z > \overline{z}$), z is substantially large, such that the cutoff productivities in each mode have the ordering of $\phi^s_{ij}(z) > \phi^g_{ij}(z) > \phi^a_{ij}(z)$. Again, with $d^s_{ij} > d^g_{ij} > d^a_{ij}$

[11]Implied in (6), it requires $e^{-\sigma\gamma z(d^s_{ij}-d^g_{ij})}(f^g_{ij}/f^s_{ij}) > 1$ to ensure $\phi^g_{ij} > \phi^s_{ij}$. Using estimated parameters that we suggested in the next section as $\sigma = 8$, $z = \underline{z} \cong 0.3$, $\gamma \in [0.006, 0.021]$, and f^g_{ij}/f^s_{ij}; 2, we obtain $0.4 < \phi^g_{ij}/\phi^s_{ij} < 1.3$. It implies that ϕ^g_{ij} might be either larger or smaller than ϕ^s_{ij}. However, when the industries are insensitive to timely delivery as $z < \underline{z}$, it is likely to have $\phi^g_{ij} > \phi^s_{ij}$ in most cases. For example,

FIG. 2. When industries are mildly sensitive to timely delivery



and $f^s_{ij} < f^g_{ij} < f^a_{ij}$, we can illustrate the profit functions in (5) in Figure 3. It shows in Figure 3 that when the industry z is highly sensitive to timely delivery, air transport likely dominates. That is, air transport remains the prevailing mode for highly time-sensitive firms.

Empirical evidence suggests that Pareto distribution is a good approximation of firms' productivities (e.g., Axtell, 2001 and Luttmer, 2007), implying that the majority of firms in an economy exhibit relatively low productivity. On the other hand, most firms are more or less time-sensitive. Conclusively, it is feasible to argue that the majority of firms in an economy, especially for the firms currently using sea transport that exhibit relatively

---

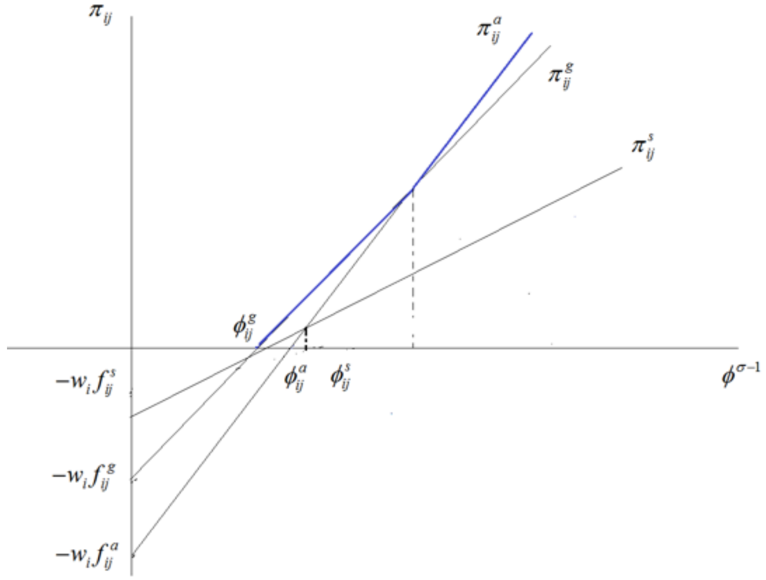
when air freight cost is substantially larger than train freight cost as f^a_{ij}/f^g_{ij}; 4, we get $\phi^s_{ij} < \phi^a_{ij}$.

[12] Again, with $d^s_{ij} > d^g_{ij} > d^a_{ij}$, the slopes of the profit function in equation (5) have the ordering as $A_{ij}e^{-d^a_{ij}\sigma\gamma z} > A_{ij}e^{-d^g_{ij}\sigma\gamma z} > A_{ij}e^{-d^s_{ij}\sigma\gamma z}$.

[13] Again, implied in (6), it requires $e^{-\sigma\gamma\underline{z}(d^s_{ij}-d^g_{ij})}(f^g_{ij}/f^s_{ij}) < 1$ to ensure $\phi^g_{ij} < \phi^s_{ij}$. Using estimated parameters suggested in the next section as $\sigma = 8$, $\gamma \in [0.006, 0.021]$, and f^g_{ij}/f^s_{ij}; 2, we obtain $e^{-\sigma\gamma z(d^s_{ij}-d^g_{ij})}(f^g_{ij}/f^s_{ij}) < 1$ if $z > 0.3$. We could simply presume a lower band $\underline{z} \cong 0.3$ for the industries are mildly sensitive to timely delivery, such that we have $\phi^g_{ij} < \phi^s_{ij}$ for these industries with $\overline{z} > z > \underline{z}$. Similarly, using the above estimated parameters, if air freight cost is substantially having f^a_{ij}/f^s_{ij}; 8, we always have $\phi^s_{ij} < \phi^a_{ij}$.

low productivity, that could be classified into the groups of either mildly time-sensitive or insensitive firms, especially the former.

FIG. 3. When industries are highly sensitive to timely delivery[14]



Therefore, as illustrated in Figure 2, we argue that ground transport is likely a prevailing mode of transportation once it becomes a cost-efficient option. This argument finds support in trade within Europe and on the North American continent as well. Trade within the European countries is dominated by ground transport (about 80%) while only 20% of goods traded within this continent is by the maritime mode.[15] Trade through land transport accounts for even a greater share (about 88%) of goods traded between the U.S. and Canada and Mexico as well since 1994.[16]

5. THE NEW SILK ROAD ECONOMIC BELT

The discussion above on different sorting cases helps explain why some firms choose shifting mode of transportation based on some characteristics.

[14]When industries are highly sensitive to timely delivery, implied in (6), we have $\phi_{ij}^{g} < \phi_{ij}^{s}$ always. However, we have $\phi_{ij}^{g} > \phi_{ij}^{a}$ only when $\gamma > 0.0144$; otherwise, $\phi_{ij}^{g} < \phi_{ij}^{a}$. Here, we don't define the ordering of ϕ_{ij}^{s} and ϕ_{ij}^{a}.

[15]See Figure 4 in Herrero and Xu (2006), who calculate from the Eurostat transport database.

[16]See the Table 1 in "North American Freight Transportation: U.S. Trade with Canada and Mexico" by Bureau of Transportation Statistics.

Suppose in a benchmark case, there are impassable geography barriers between a pairs of countries i and j, such that ground transport is not an option for firms to export. In that case, firms employ either air or sea transport to export, and their corresponding profits are illustrated by thin lines in Figure 1, 2, and 3.

After China launched its New Silk Road initiative in 2013, there are now at least 51 railway lines that directly connect 27 Chinese cities to 28 European cities and have begun operation. These intercontinental railways have significantly reduced transportation costs, making ground transport an attractive transport mode in this area. For example, Yuxinou Railway has reduced the corresponding transportation costs by 40 percent (The Hong Kong Trade Development Council 2015). Although this might not be systematically for all links. Still, it represents a significant reduction in trade cost. Therefore, once transportation infrastructure development by the New Silk Road Initiative is sufficiently realized, the geographical barriers will become passable for firms to employ ground transport. As a result, some firms that formerly use either air or sea transport might turn to ground shipping, as illustrated in Figures 1 and 2 (bold lines). However, as shown in Figure 3, when firms are highly sensitive to timely delivery, most firms will still keep employing air transport.

Suppose in a benchmark case where ground transport is basically not an option for firms engaged in international trade, the trade value between countries i, j is $X_{ij} = X_{ij}^a + X_{ij}^g + X_{ij}^s$, where $X_{ij}^g \cong 0$. While the infrastructure development in "The New Silk Road Economic Belt" makes ground transport a cost-efficient way to carry out trade, the new trade value then becomes $X\prime_{ij} = X_{ij}^{a'} + X_{ij}^{s'} + X_{ij}^{g'}$.

In terms of volume, about 87% of total goods exports from China to the 27 EU member countries were carried by sea transport, about 5.6% by ground transport, and about 1.8% by air transport.[17] Since the volume of goods were exchanged between China and Europe by air transport is negligible (less than 2%), we consider these goods are highly sensitive to timely delivery as suggested in Figure 3. We further argue that the New Silk Road has limited impact on these highly time-sensitive goods, such that most of them will still consider air transport as the cost-efficient mode of transport. This is especially very true for promotional and seasonal goods, which need to be timely delivered. Thus, for simplicity, we presume that the change in air transport is negligible with the NSR as $X_{ij} >> (X_{ij}^{a'} - X_{ij}^{a})$.

In terms of value, sea transport dominates the trade between China and Europe in 2012: 62% of total exports from China to the 27 EU member countries were delivered by sea transport, about 8% by ground transport,

[17]Data source: China Customs Database and Eurostat.

and about 23% by air transport.[18] Although the volume of goods that were exchanged between China and EU by sea transport is almost 90%, the values only account for about 60% of the value of their total traded goods. This fact copes with our argument on the above section that the firms currently using sea transport should exhibit relatively low productivity than firms using other transport modes, and the former could be classified into the groups of either mildly time-sensitive or insensitive firms.

Once ground transport is available due to China's NSR initiative, as especially suggested by Figure 2, many firms that formerly used sea transport might switch to ground transport. At most, we argue that there is about 90% of trade volume between China and Europe, accounting for about 60% of trade value between them, might be impacted by China's new silk Road. In the following, we calculate the impact of the switch in transport mode, ceteris paribus, on trade.

Recall $M_{ij}^m = M_i(b_i/\phi_{ij}^{m^*})^\theta$. With (6) and (8), we obtain the exports by ground (e.g., train) relative to by maritime as

$$\frac{X_{ij}^g}{X_{ij}^s} = \left(\frac{f_{ij}^g}{f_{ij}^s}\right)^{1-\frac{\theta}{\sigma-1}} \left(\frac{d_{ij}^s}{d_{ij}^g}\right) \left(\frac{1-e^{-\sigma\gamma d_{ij}^g}}{1-e^{-\sigma\gamma d_{ij}^s}}\right).^{19} \tag{11}$$

Let's define $\kappa = \left(\frac{f_{ij}^g}{f_{ij}^s}\right)^{\frac{\sigma-1-\theta}{\sigma-1}} \left(\frac{d_{ij}^s}{d_{ij}^g}\right) \left(\frac{1-e^{-\sigma\gamma d_{ij}^g}}{1-e^{-\sigma\gamma d_{ij}^s}}\right)$ in equation (11) to denote the multiple factor of changing transport mode. It indicates that once one unit of trade value that is formerly delivered by sea transport switch to ground transport, the cost-efficient ground transport would enlarge the total trade value by a factor of κ. With the presumption in transit days as $d_{ij}^s > d_{ij}^g$ and in freight costs as $f_{ij}^s < f_{ij}^g$, it is feasible to argue that the multiple factor $\kappa > 1$ as the transit days of sea transport is sufficiently larger than ground transport as $d_{ij}^s >> d_{ij}^g$. Thence, suppose that China's NSR initiative makes trade value of one that are formerly delivered by sea transport switch to ground transport. This switch could increase additional trade value by $\kappa - 1 > 0$ due to the fact that consumers place more values on good that are timely arrived. This is the first implication in this model.

The equation (11) implies that while ground transport helps shorten the transit time that consumers value more, hereby enlarging the market demands. We can therefore specify how China's NSR initiative might improve

[18]Data source: China Customs Database and Eurostat.

[19]With (6) and (8), we obtain $\frac{X_{ij}^g}{X_{ij}^s} = \frac{M_{ij}^g}{M_{ij}^s}\frac{f_{ij}^g}{f_{ij}^s}\frac{d_{ij}^s}{d_{ij}^g}\frac{1-e^{-\sigma\gamma d_{ij}^g}}{1-e^{-\sigma\gamma d_{ij}^s}} = \left(\frac{f_{ij}^g}{f_{ij}^s}\right)^{\frac{\sigma-1-\theta}{\sigma-1}} \left(\frac{d_{ij}^s}{d_{ij}^g}\right) \left(\frac{1-e^{-\sigma\gamma d_{ij}^g}}{1-e^{-\sigma\gamma d_{ij}^s}}\right)$.

trade as

$$\frac{\Delta X_{ij}}{X_{ij}} \cong (1-\kappa)\frac{\Delta X_{ij}^{s}}{X_{ij}},^{20} \tag{12}$$

where $\Delta X_{ij}^{s} \equiv X_{ij}^{s'} - X_{ij}^{s} < 0$ indicates the amount (in absolute value) that are formerly delivered by sea transport switch to ground transport. In the following, we use some representative data to roughly examine what the optimal tradeoff is for heterogeneous firms in the trade between, say, China and Europe.

Tradeoff Between Delivery Time and Delivery Cost

It takes about over two weeks by train, a couple days by air, and about six weeks by sea to deliver a 10-ton heavy 40-foot container from Chengdu, China to Lodz, Poland. The corresponding air freight costs are approximately US\$40,000, train freight costs are about US\$10,000, and sea freight costs are about US\$5,000 (Mount, 2015). Without loss of generality, we take the mean of several main China-EU railway routes regarding their delivery days and freight costs for each transport mode as representatives to gauge the trade-off between saving on time and saving on freight costs.

Table 1 presents the trade costs in each mode for some sample routes that were already improved with ground-based transportation through the NSR investment. As shown in Table 1, the delivery days between Europe and China are about six weeks for sea transport. Thus, we assign 48 days for sea transport as $d_{ij}^{s} \cong 48$. Ground transport takes over two weeks between Europe and China, and thus we assign 18 days for ground transport as $d_{ij}^{s} \cong 18$. Air transport takes about two to three days between Europe and China, such that we presume 3 days for air transport as $d_{ij}^{a} \cong 3$. We normalize the sea freight cost as unit, where $w_i f_{ij}^{s} \cong 1$. As mentioned above, delivering a 10-ton heavy 40-foot container from Chengdu, China to Lodz, Poland, it costs about \$ 40,000 by air, \$10,000 by train, and about \$5,000 by sea, respectively (Mount, 2015). Therefore, when normalizing the sea freight cost as unity, we obtain the corresponding train freight cost is $w_i f_{ij}^{g} \cong 2$ and air freight cost is $w_i f_{ij}^{a} \cong 8$. In our counterfactual analysis, what matters is the tradeoff of the freight costs between transport modes. Here, we have the relative freight costs of air versus ground as $f_{ij}^{a}/f_{ij}^{g} \cong 8$ and the relative freight costs of ocean versus ground as $f_{ij}^{s}/f_{ij}^{g} \cong 2$.

We consider the above case (Chengdu to Lodz) as a representative for all routes. Generally, the infrastructure of traffic network has been symmetri-

[20]We have $\frac{\Delta X_{ij}}{X_{ij}} = \frac{\Delta X_{ij}^{a}+\Delta X_{ij}^{s}+\Delta X_{ij}^{g}}{X_{ij}}$, where $\Delta X_{ij}^{m} \equiv X_{ij}^{m'} - X_{ij}^{m}$, $\forall m$. With the presumption $X_{ij}^{g} \approx 0$ and $X_{ij} >> \Delta X_{ij}^{a}$ in the case of trade between China and Europe, we therefore obtain $\frac{\Delta X_{ij}}{X_{ij}} \cong \frac{\Delta X_{ij}^{s}+X_{ij}^{g'}}{X_{ij}} = (1-\kappa)\frac{\Delta X_{ij}^{s}}{X_{ij}}$, where $X_{ij}^{g'} = -\kappa \Delta X_{ij}^{s}$ and $\Delta X_{ij}^{s} < 0$.

cally developed among the EU countries and among Chinese provinces as well. Thus, any route that links one EU country to one Chinese province will equalize the tradeoff of the freight costs between transport modes due to competition among these routes when the China's NSR is completed and fully-fledged.

TABLE 1.

Main China-EU Railway Lines

Route		Duration (days)			Freight Costs*		
From (China)	To (Europe)	Train	Air	Sea	Train	Air	Sea
Yiwu	Madrid, Spain	21	$2\sim3$	$35\sim40$	2	8	1
Yiwu	London, UK	21	$2\sim3$	$35\sim40$	2	8	1
Dongguan	Duisburg, Germany	19	$2\sim3$	$35\sim40$	2	8	1
Changsha	Duisburg/Moscow/Tashkent	18	$5\sim7$	$45\sim60$	2	15	1
Chongqing	Duisburg, Germany	15	$2\sim3$	$45\sim60$	2	4	1
Zhengzhou	Hamburg, Germany	15	$2\sim3$	$35\sim40$	2	8	1
Chengdu	Lodz, Poland	14	$2\sim3$	$45\sim60$	2	4	1
Average		18	3	48	2	8	1

* Note: Here, we normalize the freight cost of sea transport as one.
Sources: The authors collect and sort out these figures from official websites of the associate Chinese provinces.

A firm chooses its transport mode to maximize profits. First, the zero profit condition of an industry z for each mode is $\pi_{ij}^m(\phi, z) = A_{ij}e^{-d_{ij}^m\sigma\gamma z}\phi^{\sigma-1} - w_i f_{ij}^m = 0$, which leads to $\phi_{ij}^m(z) = \left(\frac{w_i f_{ij}^m}{A_{ij}} e^{d_{ij}^m \sigma\gamma z}\right)^{\frac{1}{\sigma-1}}$ for $m \in \{a, g, s\}$. Here, $\phi_{ij}^m(z)$ is the cutoff productivity in industry z, and firms with lower productivity exit the market. As mentioned in the above section, there exist two critical points of z when we come to the sensitivity of timely delivery. The lower one requires $\phi_{ij}^s(\underline{z}) = \phi_{ij}^g(\underline{z})$, where $\underline{z} = \frac{\ln(f_{ij}^g/f_{ij}^s)}{\sigma\gamma(d_{ij}^s - d_{ij}^g)}$, and firms with $z > \underline{z}$ prefer ground transport while firms with $z < \underline{z}$ prefer maritime transport. The upper one requires $\phi_{ij}^a(\overline{z}) = \phi_{ij}^g(\overline{z})$, where $\overline{z} = \frac{\ln(f_{ij}^a/f_{ij}^g)}{\sigma\gamma(d_{ij}^g - d_{ij}^a)}$, and firms with $z > \overline{z}$ prefer air transport while firms with $z < \overline{z}$ prefer ground transport.

In the literature, the estimate for the elasticity of substitution is in the range of 5 to 10 (Anderson and Van Wincoop, 2004). Particularly, Eaton and Kortum (2002) estimate the elasticity of substitution by using data of OECD countries and get a main estimate of 8.28. Using NAFTA data, Romalis (2007) finds the elasticity of substitution is in the range of 6.2 to 10.9. Here, we take the middle of these estimates in the literature and argue that the elasticity of substitution is about 8 for simplicity.

As for the time sensitivity parameter γ, Hummels and Schaur (2013) use the U.S. imports data to estimate it and argue that the γ lies in the range between 0.006 to 0.021. It implies that one day in transit is equivalent to an ad valorem tariff of 0.6 to 2.1 percent. We can use the above estimated parameters to calculate which mode of transport leads to the largest profits. As argued above, having $\sigma = 8$ and $\gamma \in [0.006, 0.021]$, we obtain an estimated $\underline{z} \in [0.14, 0.48]$ and $\overline{z} \in [0.55, 1]$.[21] Again, let's take the middle of these estimates, such that we obtain two cutoff of time-sensitivity parameters $\underline{z} \cong 0.3$ and $\overline{z} \cong 0.8$.

Arkolakis (2010) use French firm-level data to obtain an estimate of $\theta/(\sigma-1) \cong 1.5$. By using the same French firm-level data, Eaton, Kortum and Kramarz (2011) also obtain an estimation of $\theta/(\sigma-1) \cong 1.5$.[22] Thus, following the literature, we simply apply $\theta/(\sigma-1) \cong 1.5$ in our calculation. With the estimated parameters as mentioned above as $\sigma = 8$ and $\gamma \in [0.006, 0.021]$, and the sample case of freight costs information in Table 1 as $d_{ij}^g \cong 18$, $d_{ij}^s \cong 48$, $w_i f_{ij}^g \cong 2$ and $w_i f_{ij}^s \cong 1$, we can approximate the change in trade value in (11). When $\gamma = 0.006$, we obtain $\kappa = 1.2$, and when $\gamma = 0.021$, we obtain $\kappa = 1.8$.[23] That is, we obtain a range of estimates on the multiplied factors of changing to ground transport mode as $\kappa \in [1.2, 1.8]$.

As mentioned above, in terms of value, the trade transportation among European countries in 2015 is dominated by ground transport (about 80%), while only 20% of goods traded within this continent are through the maritime mode (Herrero and Xu, 2016). Comparatively, it is about 60% of total exports in terms of value from China to Europe were carried by sea transport.

Obviously, if China's "New Silk Road Economic Belt" (NSR) initiative connects Europe and Asia into one continental bloc, the ground transport cost between the EU and China would fall to some certain level. Although be unable to foresee the actual impact of the NSR as it is currently in its initial stage, it is expedient to presume an ideal state that the ground transport cost between the EU and China would fall to the same level as in the EU at most if the NSR was completed.

Based on the above optimistic estimation, ground transport might dominate the trade transportation between China and Europe, hereby accounting for up to 60% of trade value between them at most. If so, the sea mode of transport between China and Europe would drop from about 60% to 20%, with the up to 40% difference likely switching to ground transport.

---

[21] When $\gamma = 0.006$, we get $\overline{z} = 1.93 > 1$. However, with a restriction of $z \in [0, 1]$, we therefore obtain $\overline{z} \in [0.55, 1]$.

[22] In a more delicate method, Eaton, Kortum and Kramarz (2011) obtain an estimates of $\theta/(\sigma-1) \cong 2.5$.

[23] These figures are rounded off to one decimal place.

As a result, if the "New Silk Road Economic Belt" is sufficiently realized, the change in maritime mode of transport between China and Europe might almost be $-\Delta X_{ij}^s/X_{ij} \approx 40\%$. With (12), we obtain an estimation of

$$\frac{\Delta X_{ij}}{X_{ij}} \cong 0.4(\kappa - 1). \tag{13}$$

Plugging the estimated factors $\kappa \in [1.2, 1.8]$ into equation (13), we obtain $\Delta X_{ij}/X_{ij} \cong [0.08, 0.32]$. Since consumers place more values on timely arrived good in comparison to sea transport, ground transport shortens the transit time sharply at reasonable costs, hereby enlarging the market demands. Equation (13) implies that the New Silk Road of OBOR might at most create trade from China to Europe, ceteris paribus, by about additional 8% to 32%.

6. CONCLUDING REMARKS

We have developed a simple model in order to calculate possible impact of China's "The New Silk Road Economic Belt" on trade between China and Europe. Since consumers place more values on good that arrive sooner rather than later, we argue that China's NSR might make ground transport a prevailing transport mode, especially encouraging firms that currently use maritime transport to switch to ground transport as the latter shortens transit time sharply at reasonable costs, hereby enlarging the market demands. As a result, the infrastructure development of the NSR might, ceteris paribus, increase additional trade between China and Europe by about 8% to 32%, implying significant gains from trade.

We also show that the cost-efficient ground transport helps lower the productivity threshold to trade, thereby encouraging some formerly non-exporting firms to export. This further implies that the "New Silk Road Economic Belt" will improve exports, and then gains from trade for those countries involved.

However, this paper only provides a very parsimonious analysis on the impacts of OBOR on trade, while we neglect many practical aspects in our study. For example, we do not take into account a non-comparable advantage of sea transport, its loading capacity. Moreover, there are many types of goods, such as some chemicals and agricultural products, can only be transported by ship because of laws and regulations in different countries. The other costs of trade, such as tariff and non-tariff barriers, political, civic and institutional barriers are also beyond the scope of this paper.

Furthermore, it is well known that China's New Silk Road initiative is not only about trade between China and Europe but rather about trade between China and developing countries in Eastern Europe, Asia and Africa.

The benefits of trade created by China's New Silk Road for those developing countries in Eastern Europe, Asia and Africa cannot be fully evaluated based on the benefits results from lower trade costs. Since manufacturing sector developing countries in Eastern Europe, Asia and Africa is not as competitive as China's. The Belt and Road Initiative will not only facilitate connectivity of transportation infrastructure but will also enhance connectivity of many other areas, such as FDI and offshoring. The FDI and offshoring on the countries along the belt and Road will in turn improve significantly trade. We leave these issues for future researches.

REFERENCES

Aizenman, J., 2004. Endogenous Pricing to Market and Financing Cost. *Journal of Monetary Economics* **51(4)**, 691-712.

Anderson, James E. and Eric van Wincoop, 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review* **93(1)**, 170-192.

Arkolakis, Costas, 2010. Market Penetration Costs and the New Consumers Margin in International Trade. *Journal of Political Economy* **118(6)**, 1151-1199.

Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez-Clare, 2012. New Trade Models, Same Old Gains? *American Economic Review* **102(1)**, 94-130.

Axtell, Robert L., 2001. Zipf Distribution of U.S. Firm Sizes. *Science* **293**, 1818-1820.

Chaney, T., 2008. Distorted Gravity: Heterogeneous Firms, Market Structure, and the Geography of International Trade. *American Economic Review* **98**, 1707-1721.

Djankov Simeon, Caroline Freund, and Cong S. Pham, 2010. Trading on Time. *The Review of Economics and Statistics* **92(1)**, 166-173.

Eaton, Jonathan and Samuel S. Kortum, 2002. Technology, Geography, and Trade. *Econometrica* **70(5)**, 1741-1779.

Eaton, Jonathan and Samuel S. Kortum, and Francis Kramarz, 2011. An Anatomy of International Trade: Evidence from French Firms. *Econometrica* **79(5)**, 1453-1498.

Evans, C. and J. Harrigan, 2005. Distance, Time, and Specialization: Lean Retailing in General Equilibrium. *American Economic Review* **95(1)**, 292-313.

France-Presse, Agence, 2017. China Champions Globalisation with new Silk Road Summit. *The Economic Times* **May 21, 2017**.

Hallak, J. C., 2006. Product Quality and the Direction of Trade. *Journal of International Economics* **68(1)**, 238-265.

Hallak, J.C. and P. Schott, 2011. Estimating Cross Country Differences in Product Quality. *Quarterly Journal of Economics* **126(1)**, 416-474.

Herrero, Alicia Garcia and Jianwei Xu, 2016. China's Belt and Road initiative: can Europe expect trade gains? Bruegel Working Paper, issue 5.

Hummels, D. and P. Klenow, 2005. The Variety and Quality of a Nation's Exports. *American Economic Review* **95**, 704-723.

Hummels, D., 2007. Transportation Costs and International Trade in the Second Era of Globalization. *Journal of Economic Perspectives* **21**, 131-154.

Hummels, D. and G. Schaur, 2013. Time as a Trade Barrier. *American Economic Review* **103(7)**, 2935-59.

Li, Yuan, K. Bolton, and T. Westphal, 2016. The Effect of the New Silk Road Railways on Aggregate Trade Volumes between China and Europe, Working Papers on East Asian Studies, No. 109.

Luttmer, Erzo G. J., 2007. Selection, Growth, and the Size Distribution of Firms. *The Quarterly Journal of Economics* **122(3)**, 1103-1144.

Melitz, Marc J., 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* **71(6)**, 1695-1725.

Mount, Ian, 2015. Spain to China by rail: A 21st Century Silk Road Riddled with Obstacles. Fortune.

Romalis, J., 2007. NAFTA's and CUSFTA's Impact on International Trade. *Review of Economics and Statistics* **89(3)**, 416-435.

Unknown, 2017. The Trains and Sea Ports of One Belt, One Road, China's new Silk Road. *The Street Times* **May 14, 2017**.