Infrastructure Spending
and the Trade in Construction Materials

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Abstract

I use public infrastructure spending as a measure of demand for construction materials, in order to test existence of the home market effect. Arising formally in monopolistic competition trade models, the home market effect is the prediction that countries with higher demand for a good will be net exporters of that good. I construct a theoretical model that suggests goods with high transport costs and high differentiation are most likely to display home market effects. I test this prediction empirically for a handful of construction materials for which public spending is a significant portion of demand. As expected, I find that the home market effect holds for alloy steel and construction machinery. However, cement and glass display the opposite trade pattern, whereby increased domestic demand leads to reduced exports. I discuss how these results fit into the trade model framework, and how they might influence policy decisions.

1 Introduction

Public infrastructure spending is an issue of frequent political debate. It is a sizeable portion of the economy: even in the United States, which has lower levels of spending than the OECD and much of the developing world, total public spending for transportation and water infrastructure in 2007 was 2.4 percent of GDP. Infrastructure investments are generally viewed as a way to increase a country's capital stock, and therefore the productivity of all economic agents within it. In addition, spending on public projects is seen as a particularly attractive policy intervention during economic downturns, because of its immediate effect on aggregate demand.

But while it is clear that the increased demand for construction *services* will be focused domestically, it is far less obvious how this shock to demand might impact the market for construction *materials*: is the extra demand simply added to a static setup of comparative advantage in production, so that it either increases imports, decreases exports, or both? Or could it be that it actually boosts the exports of domestic producers, by helping them achieve economies of scale and thus become more competitive internationally?

A number of papers (Aschauer, 1989; Munnell, 1990; Ford et al., 1991; Morrison and Schwartz, 1992; Holtz-Eakin and Schwartz, 1995) examine the effect of public infrastructure spending on private sector productivity. However, there is no corresponding literature investigating the effect of public spending on trade patterns, which are of interest in their own right, through their link to production, employment, geo-political interests, and the trade balance. I examine the link established by the *home market effect* (HME) between government infrastructure spending and the trade in construction materials. HME is the prediction of monopolistic competition models that countries with higher demand for a differentiated good will be net exporters of that good.

Government spending on the infrastructure represents a large portion of the market for many construction materials. This allows me to use government infrastructure spending as a measure of demand in order to test the existence of the home market effect for construction materials, considered individually: does higher demand for construction steel, for instance, lead to higher exports of steel? The aim is to examine whether the set of industries that display home market effects is consistent with theory: monopolistic competition models suggest that HME holds for differentiated goods with high transportation costs.

Hanson and Xiang (2004) introduce a model with a continuum of differentiated-product industries, and exploit differences in country size to demonstrate the existence of the home market effect: they show that industries with high transport costs and low substitution elasticities (i.e., more product differentiation) tend to concentrate in the larger country, while industries with low transport costs and high substitution elasticities (i.e., less product differentiation) concentrate in the smaller country.

Hirakawa (2011) expands upon Hanson and Xiang (2004) by introducing a military sector in addition to the continuum of civilian industries, and uses government defense expenditure as a measure of demand for military goods, in order to demonstrate that the home market effect can arise from differences in government preferences over the strength of the military sector.

The current paper extends this framework beyond the military sector, to investigate the existence of the home market effect in the market for construction materials, once again using government preferences as the source of differential demand which drives production and trade patterns.

Few papers in the empirical trade literature test the home market effect for individual industries. Davis and Weinstein (1999) look at how Japanese regional variation in demand influences production of goods within industries, and find that home market effects matter for eight manufacturing sectors (out of nineteen), including "iron and steel", "electrical machinery" and "transport equipment", but not including the "stone, clay, and glass", or "general machinery" categories. Davis and Weinstein (2003) attempt the same exercise for EU trade, but have less precise estimates.

My paper contributes to the empirical trade literature by further exploring the novel home market effect estimation introduced in Hirakawa (2011), as well as by adding to the existing evidence on which industries display home market effects. From a public policy perspective, considering trade pattern responses will help us more fully understand the economic impact of infrastructure spending. Since public spending is routinely used as a policy intervention tool to stimulate the domestic economy, it becomes particularly important to understand whether part of that induced demand is transferred abroad, or whether instead there is a more than proportional positive effect on domestic production through the home market effect.

2 Theoretical model and predictions

I model two types of goods: a continuum of differentiated consumer product industries, whose goods are demanded by individual consumers, and a group of construction materials, demanded only by the government.[1] I will further assume that government demand for materials has a Cobb-Douglas functional form, so a fixed portion of infrastructure spending is allocated to each material; this is in order to keep the model tractable, although I do not expect qualitative predictions to be different even if spending on different materials were price elastic, within reasonable bounds.

There is a large country and a small country. Each has one factor of production: labor. The large country has a mass $L > 1$ of workers, each earning wage w. The small country's labor endowment and wage are normalized to 1 (so $w^*L^* = 1$). Each country's infrastructure spending budget I (I^*) is extracted from workers' income by lump-sum taxation, so that workers will have after-tax income $Y = wL - I$ ($Y^* = 1 - I^*$) to spend on consumer goods, while governments spend I (I^*) on construction goods.

[1] In reality, the private sector also demands construction materials, but I abstract away from this for the sake of simplicity. I acknowledge the concern that, if governments seek to spur demand during economic downturns, infrastructure spending will be counter-cyclical and so ignoring private spending on construction materials may bias results. However, in practice, my sample shows no correlation between GDP and infrastructure spending as a share of GDP, after controlling for country fixed effects.

2.1 Consumer goods

Consumer goods are modeled on a continuum, in order to allow for variation in differentiation and transport costs - the two dimensions that will determine which industries display home market effects. In particular, I consider a continuum of monopolistically competitive industries (as introduced by Dixit and Stiglitz, 1977) indexed by $z \in [0, 1]$. Consumers derive utility from purchasing many different varieties of a given product. Firms continue to enter until the last firm just breaks even. Since cost structures are identical across firms, in equilibrium all firms have zero profits.

First, I outline the consumers' problem: individuals have Cobb-Douglas preferences over industries, and constant elasticity of substitution (CES) demand over varieties within an industry:

$$U_{\text{consumer}} = \prod_{z\in[0,1]} \left[\left(\sum_{i=1}^{n(z)} q_{zi}^{\frac{\sigma(z)-1}{\sigma(z)}} \right)^{\frac{\sigma(z)}{\sigma(z)-1}} \right]^{\alpha(z)}$$

In the equation above, $\alpha(z)$ is the consumption share of industry z products and $\int_0^1 \alpha(z)dz = 1$; $n(z)$ is the number of product varieties in industry z, $\sigma(z)$ is the elasticity of substitution between varieties (restricted to be larger than one), and q_{zi} is the quantity of variety i in industry z.

Let $\tau(z) > 1$ be the iceberg transport cost incurred in shipping one unit of output from one country to the other, and $x(z) = \tau(z)^{\sigma(z)-1}$ the effective trade cost[2] for industry z.

I will assume there is no international specialization at the industry level, meaning each country produces some goods in each industry. The varieties of industry z are symmetric: let $c(z)$ be the fixed labor requirement, and I normalize the variable labor requirement for each variety to one. Then output and price are the same for all varieties: $q_{zi} = q(z)$, $p_{zi} = p(z)$. As a result of the CES demand specification, the price is a constant markup over marginal cost (in this case, wage w):

$$p(z) = \frac{\sigma(z)}{\sigma(z)-1} w \tag{1}$$

Since free entry drives profits to zero, output is fixed and revenues are proportional to fixed costs: $\Pi(z) = p(z)q(z) - [c(z)w + qw] = 0$, and we replace the expression for $p(z)$ from equation

[2] As in all monopolistic competition models, transport costs matter more for industries with high elasticity of substitution. The exact specification of x will become obvious shortly in the model derivation.

(1) to find:

$$\begin{aligned} q(z) &= c(z)[\sigma(z) - 1] \\ p(z)q(z) &= wc(z)\sigma(z) \end{aligned}$$

2.2 Construction materials

The government has Cobb-Douglas demand over different types of construction materials ($\gamma(m)$ indicates the share of government spending allocated to each good: $\sum_{m=1}^{M} \gamma(m) = 1$). Even within a certain class of materials (e.g. construction steel), there are many varieties used in construction projects, each clearly differentiated from the others, and with its specific purpose. Therefore at the variety level demand is CES, as in the case of consumer goods.

$$U_{\text{government}} = \prod_{m=1}^{M} \left[\left(\sum_{i=1}^{n(m)} q_{mi}^{\frac{\sigma(m)-1}{\sigma(m)}} \right)^{\frac{\sigma(m)}{\sigma(m)-1}} \right]^{\gamma(m)}$$

where $m = 1, ..., M$ indexes construction materials, of which we assume there is a finite number. The same industry-level algebra from consumer good z carries through for construction material m.

$$\begin{aligned} p(m) &= \frac{\sigma(m)}{\sigma(m) - 1} w \\ q(m) &= c(m)[\sigma(m) - 1] \\ p(m)q(m) &= wc(m)\sigma(m) \end{aligned}$$

2.3 Trade equilibrium

I arrive at the following equilibrium condition:

$$0 = \int_0^1 \alpha(z)g(z)dz + \sum_{m=1}^{M} \gamma(m)g(m) \tag{2}$$

$$\text{where} \quad g(z) = \left[\frac{Y}{x(z)w^{\sigma(z)} - 1} - \frac{Y^*}{x(z)w^{-\sigma(z)} - 1}\right] \tag{3}$$

$$g(m) = \left[\frac{I}{x(m)w^{\sigma(m)} - 1} - \frac{I^*}{x(m)w^{-\sigma(m)} - 1}\right] \tag{4}$$

Both $g(z)$ and $g(m)$ are strictly decreasing in w, so equation (2) has a unique solution $w > 1$, as long as $\left[(Y - Y^*) \int_0^1 \frac{\alpha(z)dz}{x(z)-1} + (I - I^*) \sum_{m=1}^{M} \frac{\gamma(m)}{x(m)-1}\right] > 0$, a sufficient condition for which is that both the consumer goods and construction materials sectors of the big country are larger than those of the small country.[3]

It is then easy to show that functions $g(z)$ and $g(m)$ code the trade-offs in the strategic decision over location faced by firms and, they are the key to whether a certain industry displays home market effects or not. Mirroring the arms paper, I then define the home market effect as follows:

Definition - home market effect

Industry z is said to show home market effects if the country with higher demand for z produces a larger share of world z output than its share of world demand for z. In my 2-country world, that translates to:

a) For civilian industries indexed by z: $\frac{n(z)p(z)q(z)}{n^*(z)p^*(z)q(z)} = \frac{n(z)w}{n^*(z)} > \frac{\alpha(z)Y}{\alpha(z)Y^*} = \frac{Y}{Y^*}$.

Define $\tilde{n}(z) = n(z)w$. Then the condition is $\tilde{n}(z)/\tilde{n}^*(z) > \frac{Y}{Y^*}$ or $n(z)/n^*(z) > \frac{Y/w}{Y^*}$, which I can then show is equivalent to $g(z) > 0$.

b) Under the assumption that the larger country (Home) also has higher infrastructure spending ($I > I^*$), the construction materials sector displays the home market effect if and only if $\tilde{n}(m)/\tilde{n}^*(m) > \frac{I}{I^*} \Leftrightarrow n(m)/n^*(m) > \frac{I/w}{I^*}$. This can be shown to be equivalent to $g(m) > 0$.

I then arrive at the following proposition:

Proposition 1

Let z_0 be a civilian industry so that $g(z_0) > 0$; then $g(m) > 0$ if $x(m) \geq x(z_0)$, $\sigma(m) \leq \sigma(z_0)$, and $I/I^* \geq Y/Y^*$. In particular, I isolate two cases:

[3] Thoroughly demonstrating the existence of this result, under a general number M of construction materials, is an involved analytical exercise that will require certain non-trivial continuity assumptions. A way to simplify the proof is to consider each construction material individually - i.e. set M=1, and use the proof from Hirakawa (2011).

(a) $x(m) > x(z_0)$, $\sigma(m) < \sigma(z_0)$, and $I/I^* \geq Y/Y^*$

(b) $x(m) \approx x(z_0)$, $\sigma(m) \approx \sigma(z_0)$, and $I/I^* \geq Y/Y^*$

The reverse also holds: if $g(z_0) < 0$ for some z_0, then $g(m) < 0$ if $I/I^* \leq Y/Y^*$, $x(m) \leq x(z_0)$ and $\sigma(m) \geq \sigma(z_0)$.

Proposition 1 states that if a consumer goods industry z_0 shows home market effects, so will the industry for construction material m, as long as m has at least as high effective trade costs and is at least as differentiated as z_0, and as long as Home's infrastructure spending relative to Foreign is higher than Home's consumer goods spending.

As before, when we switch from comparing two consumer industries to comparing government-demanded goods vs. consumer goods, the key difference is that home market effects can arise not just from differences in goods' characteristics, but also from differences in relative public to private spending (as shown in part b of proposition 1). The construction materials sector is much more likely to display home market effects if Home has higher infrastructure spending relative to GDP than Foreign.

2.4 Empirical specification

The derivation proceeds as in Hirakawa (2011).

Compare country j's exports of goods i and o to country k (S_{ijk} and S_{ojk}), with some other country h's exports, also to country k (S_{ihk} and S_{ohk}). If industry i is a construction material and o is a consumer goods industry of equal or lower transport costs and equal or higher σ, proposition 1 suggests that $\frac{\tilde{n}_{ij}/\tilde{n}_{ih}}{\tilde{n}_{oj}/\tilde{n}_{oh}}$ will be increasing in $\frac{I_j/I_h}{Y_j/Y_h}$. That result was obtained under the condition that $Y_j > Y_h$ and $I_j > I_h$, therefore I order exporter pairs so that the first exporter (j) is larger, and I restrict the sample so that exporter 1's infrastructure spending is also larger than that of exporter 2 (h). I then estimate the regression:

$$ln\left(\frac{S_{ijk}/S_{ihk}}{S_{ojk}/S_{ohk}}\right) = \alpha + \beta \ln\left(\frac{I_j/I_h}{Y_j/Y_h}\right) + \phi(X_j - X_h) + \theta ln(d_{jk}/d_{hk}) + \epsilon_{iojkh} \quad (5)$$

where $\frac{I_j/I_h}{Y_j/Y_h}$ is the relative infrastructure spending out of GDP of the two exporters, X_j and X_h control for the production costs of industries i and o in the two exporter countries, and d_{jk} and d_{hk} are distances from each of the exporters to the common importer. A positive β coefficient is evidence of the home market effect.

Consumer goods o are taken to be *control* goods (lower transport costs and higher elasticity of substitution). At a later time, I will consider *similar* goods (approximately equal transport costs and differentiation). I expect the β coefficient to be positive and significant in both cases, but higher in the former case.

3 Data

Internationally-comparable infrastructure spending data are limited. The only international panel data available is the one collected by Eurostat - the statistical office of the European Union - in their *General Government Expenditure by Function database*. Table (1) shows the level of disaggregation available in government spending; in red italics I marked the categories most likely to make wide use of construction materials.

As these data are collected and disseminated by Eurostat, and reporting is voluntary, the sample is limited to European countries, in particular a subset of EU member countries. Data availability start years by country are shown in table (2); the end year is 2008, which is not constraining, since the trade data I employ runs through 2007.

Table (3) lists the expenditure categories initially considered, and the construction materials for which these government expenditures capture a large portion of the market. Note for instance that, while cement is certainly used in housing developments as well, it would be inappropriate to use public spending on housing as a measure of demand for cement, since overall transportation spending is much higher than public housing spending, and different types of public spending are not independent.

I use bilateral trade data from UN Comtrade, classified by the Harmonized System at the 6-digit level, from 1990 through 2007.

To proxy for the distance variable d from equation (5), I use both physical distance, and distance in terms of cultural similarity: I obtained inter-capital distance data and indicators of common language, contiguity, and past colonial relationship from *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII).

The X vector of variables is intended to control for production costs across industries, and it includes capital per worker data from the Penn World Tables 5.6, average total years of education from the Barro and Lee (2001) dataset, and land per worker from the World Bank's World Development Indicators (WDI). GDP was also extracted from the World Bank's WDI.

In this preliminary version of the paper, the set of *control* goods is the one identified relative to the arms sector in Hirakawa (2011), and listed in table (4); in the next step I will select a set of control goods separately for each *treatment* good considered (i.e. with higher elasticity of substitution and lower transport costs than the given treatment good).

4 Government transportation spending

Government expenditure on transport (which includes building and maintenance of roads, bridges, airports, railways, etc.) is a large spending category, which routinely averages over 2 percent of GDP in OECD countries. There are a handful of easily identifiable large inputs into transport infrastructure construction, including steel, cement, asphalt, and construction machinery.

Graph (1) shows the variation of transport expenditure out of GDP vs. GDP for the countries in the sample. It shows that infrastructure spending is relatively stable, but it does fluctuate, and it shoots up during certain periods - this is not the same calendar year across countries, although average spending was higher earlier in the sample (early 1990s) and evened off during the 2000s.

4.1 Steel

Steel used in road and bridge construction (as well as construction of related buildings) is alloy steel (but not stainless), in different forms, including rods, bars and wire. In table (5) I list in red italics the types of steel most used in the construction of transportation infrastructure, by the Harmonized System classification.

Construction steel is made in large part from scrap steel, which is traded in large quantities. Therefore, production is not linked to natural resources availability to such an extent that raw inputs other than labor need enter the model. In addition, there are many different grades of steel, each with their own specialized uses, therefore making CES demand and monopolistic competition a suitable theoretical framework to describe steel manufacturing.

The construction steel categories marked in table (5) map mainly into Standard International Trade Classification (SITC) revision 3 categories 675, 676, as well as 672 and 678. Figure (2) shows how these four categories place in the spectrum of industries in terms of transport costs and differentiation, using the same estimates as in the arms paper: freight rate from Hanson and Xiang (2004) and substitution elasticities from Broda and Weinstein (2006). It appears that, while transport costs are significant, differentiation varies, with the bulk of construction steel (categories 675 and 676) being relatively homogeneous.

As mentioned before, the control industries indicated here and used in regressions are still the ones isolated with respect to military weapons. Figure (2) shows that these control goods are on average as homogeneous, or more so, than steel categories, and have significantly lower transport costs.

I estimate equation (5), where the construction material is represented by the group of non-stainless alloy steel categories discussed, and public transportation spending stands in for exporters' infrastructure spending I. Results are displayed in table (6). The preferred specification dictated by the model is shown in column 3. I also experiment with holding back some controls (columns 1 and 2), or restricting the sample (column 4) in order to separate the effect of sample composition from the effect of adding endowment controls as we switch from the 2nd to the 3rd specification. Column 5 introduces a control for relative GDP, to ensure results are not an artifact of differences in country size. The coefficient on the differenced ratio of transportation spending to GDP is positive and significant across all specifications, indicating strong home market effects. The coefficient in column 3 suggests that a 10 percent increase in transportation infrastructure spending is associated with a 14.9 percent increase in exports of alloy steel (recall that any increase in exports would be evidence of the home market effect).

All other coefficients have the expected signs: greater distance between countries makes it less likely to ship a heavy product like steel, but being neighbors increases the volume of steel trade; past colonial relationship has a positive effect, which suggests historical bilateral trade relationships in steel; high capital endowment is a plus, but large country area is a (weak) minus. Education and shared language are inconsequential, meaning production and trade in steel require a similar level of skill and communication as the control goods.

4.2 Machinery

I have isolated the following three categories of machinery and vehicles most likely to be used in construction projects.

8429	Self-propelled bulldozers, angledozers, graders, levellers, scrapers, mechanical shovels, excavators, shovel loaders, tamping machines and road rollers.
870510	Crane lorries.
870540	Concrete-mixer lorries.

Construction machinery (HS=8429) maps into SITC category 723. Crane and concrete-mixer lorries (HS=870510 and 870540) map into category 782, which also contains vehicles for the transportation of goods, so it has been omitted from the graph of substitution elasticity σ vs. freight rate. Figure (3) shows that construction machinery is a little above average in terms of differentiation, and a little below average in transport costs (4th decile of both σ_{BW} and freight rate).

Regression results indicate that construction machinery (including crane and concrete-mixer lorries) does display home market effects when controlling for capital, labor and education, although the result is insignificant in absence of these controls (see table 7).

I interpret these results to mean that, unlike for steel, endowment measures (especially capital and education) are needed here to control for different production capabilities and costs. Machinery and vehicles require a higher degree of know-how than steel production, as well as access to more sophisticated technology. Nonetheless, once these differences are accounted for, domestic demand has a positive effect on exports, in other words the home market effect carries through.

4.3 Cement

Cement is widely used in the construction of roads, bridges, and airports. It is captured in the Harmonized System by category 2523: "Portland cement, aluminous cement, slag cement, super-sulphate cement and similar hydraulic cements, whether or not colored or in the form of clinkers." The corresponding 3-digit SITC category is 661: "Lime, cement, and fabricated construction materials (except glass and clay materials)", which includes asphalt. Figure (4) shows that cement has median differentiation (5th decile of σ_{BW}), but very high transport costs.

Table (8) shows regression results for cement (HS=2523), and table (9) restricts the product sample to just Portland cement (HS=252329 - the type of cement most commonly used in road construction). Results are consistent with the idea that cement production is sticky: the relevant coefficient is *negative* and significant: the more a country spends on transport infrastructure, the less it exports cement products.

One possibility to consider is that transport costs are too extreme for the home market effect to hold. Figure 5 shows that cement (SITC 661) has the second highest freight rate among all industries for which the data is available. The only category with higher transport costs is *Clay construction materials and refractory construction materials* (SITC 662). I test existence of the home market effect for this industry, by using country size differences as in Hanson and Xiang (2004), and find no empirical evidence that trade patterns are correlated with country size (results not reported). This is consistent with the intuition that goods with prohibitively high transport costs will simply not be traded, and so varying demand will not impact trade in either direction. However, the relevant coefficients in tables (8) and (9) are significantly negative, rather than zero, suggesting that high transport costs are not a complete explanation.[4]

To explain a *reverse* home market effect, we need to consider the specifics of cement production in more detail. Cement is produced using non-metallic minerals like limestone, clay and gypsum. These have high transport cost to value ratios, and are therefore not traded in significant quantities. Another major input into cement production is electricity. As these inputs are not traded and have decreasing returns to scale beyond an initial efficient scale, they explain why production does not relocate with changes in demand. Yes another driver of this stickiness in production is the pollution

[4]Chad Syverson (Syverson, 2004, 2007) discusses how, due to extreme transport costs, the market for ready-mix *concrete* is focused on satisfying local demand. However, *cement* (before being mixed into concrete) is not prohibitively expensive to move across large distances, and it is traded internationally.

associated with cement manufacturing, which requires somewhat lax environmental regulations. The result is that regions and countries that experience surges in demand will have to respond by decreasing their exports and increasing their imports of cement, consistent with the pattern I am observing.

4.4 Asphalt

Asphalt (also known as bitumen) is a good candidate to test the model empirically, because its primary use is in road construction, where it is used as the glue or binder mixed with aggregate (sand and gravel) particles to create asphalt concrete.

Similarly to cement, shipping asphalt is expensive, but not prohibitively so,[5] and its production does display scale economies, which suggests we should expect the home market effect to hold.

However, asphalt is a petroleum product - it is obtained from either natural deposits or as a byproduct of the petroleum industry (petroleum asphalt). Since production is tied to the extraction and processing of oil or other natural deposits, and is further limited by environmental regulations, producers may not be able to relocate in response to demand changes. Regression results in table (10) show that, indeed, asphalt exports drop slightly, although not significantly, in response to increases in domestic demand.

5 Housing expenditure

Transportation spending far outranks all other types of government infrastructure expenditure, which is what makes it a top pick for this exercise. Another key factor is that different types of government spending are correlated, whether they are substitutes or complements. As an example, housing and transportation infrastructure spending are positively correlated for some countries (Ireland .80, UK .79, Bulgaria .67). For other countries, there is strong negative correlation (Sweden -.82, Poland -.76, Norway -.49).

As I explore the possibility of using another spending category, aside from transportation, the challenge is identifying construction materials that are relevant to it, but which are *not* major inputs into road and bridge construction. For example, cement is a significant input into housing developments, but since it is also widely used in transportation infrastructure projects, and transportation spending is almost one order of magnitude higher than spending housing developments, I cannot claim that housing expenditure is a good demand measure for cement.

[5] Recall that asphalt is captured in the wider SITC=661 cement category depicted in figure (4).

One construction material used in housing development but far less in transportation-related projects is glass.[6] I use this fact to test the model using public housing spending as well.

5.1 Glass

Table (11) lists all products in the Harmonized System *glass and glassware* category. Goods used in construction are marked in red italics.

The SITC category that best corresponds to this group of goods is 664: glass, not including glassware. As figure (7) shows, glass is well differentiated and has high (but not extreme) transport costs - making it an ideal candidate for home market effects.

However, results reported in table (12) suggest that, like cement, glass clearly displays the reverse of the home market effect. Some of the same arguments discussed for cement apply, as well: high fixed costs mean there is a long lag in capacity adjustment to changes in demand, so in the short to medium run excess demand is accommodated through increased imports. Production involves large quantities of heavy and inexpensive (therefore non-traded) inputs, including fresh water, therefore production locates close to input availability points. Additionally, glass manufacturing processes impact the local environment negatively through noise, water and air pollution[7] - this makes it very costly, time consuming, or even impossible to open factories in some locations, or expand existing ones.

6 Conclusion

Construction steel and machinery display home market effects, in agreement with the theoretical model proposed, but cement and glass exhibit the opposite pattern: for these latter industries (as well as perhaps for asphalt, where the result is not statistically significant), higher demand leads to reduced exports. Further consideration of the specifics of production of cement, asphalt and glass suggest that a single-input production model as in the standard monopolistic competition approach may simply not be suitable to describe these industries, which utilize non-traded inputs, are energy intensive and highly polluting. Local comparative advantage appears to play a larger part in establishing production location than geographic variation in demand.

It is also helpful to keep in mind that, if capacity adjustment is slower in certain industries like cement, it may be difficult to tease out the effect of changing demand on long-term production,

[6] With the caveat that transportation spending includes construction of airports, train stations, etc, which do make use of glass.

[7] One source of air pollution is transportation of the dusty inputs.

and standard trade models which assume instantaneous adjustment may again not be suitable.

My results are in agreement with previous estimates by Davis and Weinstein (1999), who found home market effects for "iron and steel", "electrical machinery" and "transport equipment", but not for "stone, clay, and glass".

In terms of practical short-run implications, these results suggest that we can expect the steel industry to expand as a result of increased domestic infrastructure spending. Conversely, the trade balance will drop (i.e., become more negative) when domestic demand for cement or glass spikes. This suggests that, given a choice between stimulus spending in different types of infrastructure projects, the government should favor steel- and machinery-intensive projects if the goal is to increase domestic employment and improve the trade balance.

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Tables

Table 1: Government expenditure categories - Eurostat data

01		General public services
02		Defence
03		Public order and safety
04		Economic affairs
	04.1	General economic, commercial and labour affairs
	04.2	Agriculture, forestry, fishing and hunting
	04.3	Fuel and energy
	04.4	Mining, manufacturing and construction
		Administration, policing of these industries.
	04.5	***Transport***
		Includes construction and maintenance of road, water, railway, air, pipeline and other transport systems.
	04.6	*Communication*
		Includes construction and maintenance of communication systems (postal, telephone, telegraph, wireless, satellite)
	04.7	Other industries
	04.8	R&D Economic affairs
	04.9	Economic affairs n.e.c.
05		Environmental protection
	05.1	Waste management
	05.2	*Waste water management*
		Includes construction and maintenance of sewer lines (also treatment plants?)
	05.3	Pollution abatement
	05.4	Protection of biodiversity and landscape
	05.5	R&D Environmental protection
	05.6	Environmental protection n.e.c.
06		Housing and community amenities
	06.1	***Housing development***
	06.2	Community development
		Community planning, excludes implementation.
	06.3	*Water supply*
		Includes construction and operation of potable water supplies.
	06.4	*Street lighting*
		Excludes highway lighting
	06.5	R&D Housing and community amenities
	06.6	Housing and community amenities n.e.c.
07		Health
08		Recreation, culture and religion
09		Education
10		Social protection

Table 2: Data availability by country

Start year	Countries
1990	Norway
1995	Ireland, Czech Rep, Estonia, Spain, Cyprus, Luxembourg, Hungary, Austria, Portugal
1996	United Kingdom
2000	Bulgaria, Germany, Italy, Lithuania
2001	Greece, Malta, Sweden
2002	Poland, Finland
2005	Slovenia
2007	Latvia

Table 3: Expenditure categories and corresponding construction materials

Gov't expenditure category	**Candidate materials**
Transportation infrastructure	Steel Cement Asphalt Machinery
Housing development	Glass

Table 4: Set of control goods

	SITC rev 3 description	freight rate	σ	HS concordance
714	Engines and motors, nonelectric	0.0217	2.37	8411
792	Aircraft and associated equipment; spacecraft	0.0295	4.98	8801-3, 8805
896	Works of art, collectors' pieces and antiques	0.0323	2.23	9701-6
525	Radioactive and associated materials	0.0331	1.35	2844-6
752	Computers	0.0333	2.18	8471
542	Medicaments	0.0338	2.65	3003, 3004
761	TV receivers	0.0364	2.8	8528
683	Nickel	0.0402	4.04	7502, 7504-7
515	Organo-inorganic compounds	0.0404	1.55	2930-2935
687	Tin	0.0409	3.65	8001, 8003-6
874	Measuring and analysing instruments	0.0440	1.55	9014-7,9023-7,9030-3
782	Motor vehicles for the transport of goods	0.0445	6.7	8704-5
514	Nitrogen-function compounds	0.0475	1.48	2921-9
881	Photographic apparatus and equipment, n.e.s.	0.0477	1.48	9006-8, 9010
531	Synthetic organic coloring matter	0.0504	25.03	3204-5
746	Ball or roller bearings	0.0512	1.63	8482

Table 5: Iron and steel (HS=72) subcategories

7201-7205	[Primary materials]
7206-7217	[Iron and non-alloy steel]
7218-7223	[Stainless steel]
Other alloy steel	
7224	*Other alloy steel in ingots or other primary forms; semi-finished products of other alloy steel.*
7225	*Flat-rolled products of other alloy steel, of a width of 600 mm or more.*
7226	*Flat-rolled products of other alloy steel, of a width of less than 600 mm.*
7227	*Bars and rods, hot-rolled, in irregularly wound coils, of other alloy steel.*
7228	*Other bars and rods of other alloy steel; angles, shapes and sections, of other alloy steel; hollow drill bars and rods, of alloy or non-alloy steel.*
7229	*Wire of other alloy steel.*

Table 6: Analysis for *alloy steel, other than stainless*

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(trans/GDP)	1.22	1.08	1.49	1.37	1.31
	(.20)***	(.20)***	(.28)***	(.31)***	(.23)***
distance		-.36	-.45	-.60	-.24
		(.13)***	(.12)***	(.22)***	(.12)**
colonial relationship		-.33	.71	.34	.81
		(.19)*	(.26)***	(.31)	(.25)***
common language		.16	-.31	.02	-.55
		(.25)	(.36)	(.36)	(.33)*
common border		.79	.61	.70	.67
		(.17)***	(.27)**	(.35)**	(.26)***
capital/worker			1.75		2.48
			(.53)***		(.52)***
land/worker			-.54		-1.17
			(.32)*		(.34)***
years schooling			-.008		.13
			(.86)		(.82)
ln(GDP)					-.97
					(.36)***
Obs.	16265	16265	7685	7685	7685
e(N-clust)	226	226	68	68	68
R^2	.06	.08	.2	.15	.22

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Table 7: Analysis for construction machinery and vehicles

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(trans/GDP)	.07	.03	.57	.21	.48
	(.16)	(.16)	(.18)***	(.21)	(.17)***
distance		-.11	-.09	-.35	.03
		(.13)	(.13)	(.22)	(.11)
colonial relationship		.005	.30	-.11	.35
		(.14)	(.22)	(.27)	(.22)
common language		.32	.29	.68	.09
		(.22)	(.29)	(.30)**	(.29)
common border		.44	.41	.44	.45
		(.13)***	(.17)**	(.21)**	(.16)***
capital/worker			1.57		2.07
			(.36)***		(.42)***
land/worker			-.88		-1.32
			(.25)***		(.30)***
years schooling			.60		.73
			(.73)		(.69)
ln(GDP)					-.64
					(.30)**
Obs.	13552	13552	7673	7673	7673
e(N-clust)	227	227	68	68	68
R^2	.03	.04	.15	.07	.17

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Table 8: Analysis for *cement* (HS=2523)

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(trans/GDP)	-.85	-1.17	-1.40	-1.39	-1.42
	(.29)***	(.26)***	(.31)***	(.34)***	(.30)***
distance		.21	-.09	.25	-.004
		(.15)	(.15)	(.18)	(.18)
colonial relationship		-.02	-.65	-.21	-.62
		(.27)	(.30)**	(.32)	(.29)**
common language		-1.17	-1.32	-1.76	-1.46
		(.33)***	(.32)***	(.35)***	(.30)***
common border		3.02	3.08	3.05	3.10
		(.30)***	(.25)***	(.29)***	(.24)***
capital/worker			-2.05		-1.75
			(.33)***		(.41)***
land/worker			.29		.03
			(.19)		(.23)
years schooling			-1.71		-1.72
			(.61)***		(.62)***
ln(GDP)					-.38
					(.33)
Obs.	5893	5893	3337	3337	3337
e(N-clust)	210	210	67	67	67
R^2	.09	.2	.32	.23	.32

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Table 9: Analysis for *Portland cement* (HS=252329)

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(trans/GDP)	-.17	-.65	-1.73	-1.41	-1.56
	(.43)	(.38)*	(.40)***	(.42)***	(.37)***
distance		.93	.54	.92	.78
		(.22)***	(.26)**	(.27)***	(.29)***
colonial relationship		.34	-.07	-.08	-.05
		(.32)	(.47)	(.49)	(.49)
common language		-.45	-.67	-1.08	-1.06
		(.42)	(.53)	(.56)*	(.54)**
common border		3.70	3.43	3.75	3.36
		(.38)***	(.48)***	(.59)***	(.41)***
capital/worker			-.78		.24
			(.50)		(.63)
land/worker			.80		-.16
			(.36)**		(.39)
years schooling			-2.72		-2.62
			(.69)***		(.67)***
ln(GDP)					-1.15
					(.48)**
Obs.	2461	2461	1353	1353	1353
e(N-clust)	174	174	62	62	62
R^2	.17	.3	.36	.34	.38

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Table 10: Analysis for *asphalt*

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(trans/GDP)	-.05	-.18	-.36	-.17	-.37
	(.27)	(.26)	(.33)	(.33)	(.33)
distance		.06	-.44	-.36	-.41
		(.19)	(.21)**	(.23)	(.17)**
colonial relationship		-.15	.07	-.01	.07
		(.24)	(.32)	(.31)	(.31)
common language		-.99	-1.07	-.99	-1.09
		(.32)***	(.36)***	(.39)**	(.35)***
common border		1.50	1.60	1.67	1.61
		(.20)***	(.26)***	(.27)***	(.26)***
capital/worker			.52		.61
			(.47)		(.51)
land/worker			.22		.14
			(.25)		(.34)
years schooling			-.91		-.89
			(1.04)		(1.05)
ln(GDP)					-.11
					(.40)
Obs.	7860	7860	4974	4974	4974
e(N-clust)	196	196	68	68	68
R^2	.06	.09	.15	.14	.15

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Table 11: Glass and glassware (HS=70) categories

70	Glass and glassware
7001	Glass cullet, waste or scrap, glass in the mass.
7002	*Glass in balls (other than microspheres of heading No. 70.18), rods or tubes, unworked.*
7003	*Cast and rolled glass, in sheets and profiles, whether or not having an absorbent, reflecting or non-reflecting layer, but not otherwise worked.*
7004	*Drawn or blown glass, in sheets.*
7005	*Float glass, surface ground, polished glass in sheets.*
7006	*Glass of heading No. 70.03, 70.04 or 70.05, bent, edge-worked, engraved, drilled, enamelled or otherwise worked, but not framed or fitted with other materials.*
7007	*Safety glass, consisting of toughened (tempered) or laminated glass.*
7008	*Multiple-walled insulating units of glass.*
7009	Glass mirrors, whether or not framed, including rear-view mirrors.
7010	Glass bottles, flasks, jars, phials, stoppers, etc
7011	Glass envelopes (including bulbs and tubes), open, and glass parts thereof, without fittings, for electric lamps, cathode-ray tubes or the like.
7012	Glass inners for vacuum flasks, other vacuum vessels.
7013	Glassware for table, kitchen, toilet, decoration.
7014	Signalling glassware, unworked optical elements.
7015	Glasses for spectacles, clocks, watches, unworked.
7016	*Paving blocks, slabs, bricks, squares, tiles and other articles of pressed or moulded glass, whether or not wired, of a kind used for building or construction purposes; glass cubes and and other glass smallwares.*
7017	Laboratory, hygienic or pharmaceutical glassware etc.
7018	Glass beads, imitation stones (not jewel), ornaments.
7019	Glass fibres, glass wool, and articles thereof (for example, yarn, woven fabrics).
7020	Articles of glass, nes.

Table 12: Analysis for glass used in construction (HS=7002-7008, 7016)

	s1	s2	s3	s3-sample	s5
	(1)	(2)	(3)	(4)	(5)
ln(hous/GDP)	-.49	-.59	-1.04	-.88	-1.02
	(.16)***	(.15)***	(.21)***	(.20)***	(.23)***
distance		-1.05	-1.06	-.65	-1.09
		(.13)***	(.13)***	(.18)***	(.14)***
colonial relationship		-.73	-.43	-.24	-.44
		(.20)***	(.25)*	(.28)	(.25)*
common language		-.02	-.44	-.63	-.41
		(.27)	(.23)*	(.31)**	(.22)*
common border		.85	1.51	1.74	1.50
		(.16)***	(.25)***	(.30)***	(.26)***
capital/worker			-.75		-.86
			(.72)		(.68)
land/worker			-.19		-.09
			(.26)		(.35)
years schooling			-1.14		-1.20
			(1.02)		(1.07)
ln(GDP)					.13
					(.33)
Obs.	23811	23811	9016	9016	9016
e(N-clust)	220	220	61	61	61
R^2	.04	.12	.27	.2	.27

Notes: dep. variable = $\ln\left(\frac{S_{cjk}/S_{chk}}{S_{ojk}/S_{ohk}}\right)$: flow of construction materials (c) from exporters j and h to importer k, vs. flows of control goods (o). Exporters are ordered so that exporter 1 has higher GDP, and the sample is restricted so that exporter 1 also has higher gov't expenditure. Year and importer country dummies are included in all regressions. Exporter-pair clustered standard errors are shown in parentheses. Significance indicated is at 10%(*), 5%(**), and 1%(***).

Figures

Figure 1: Transport infrastructure spending out of GDP vs. GDP

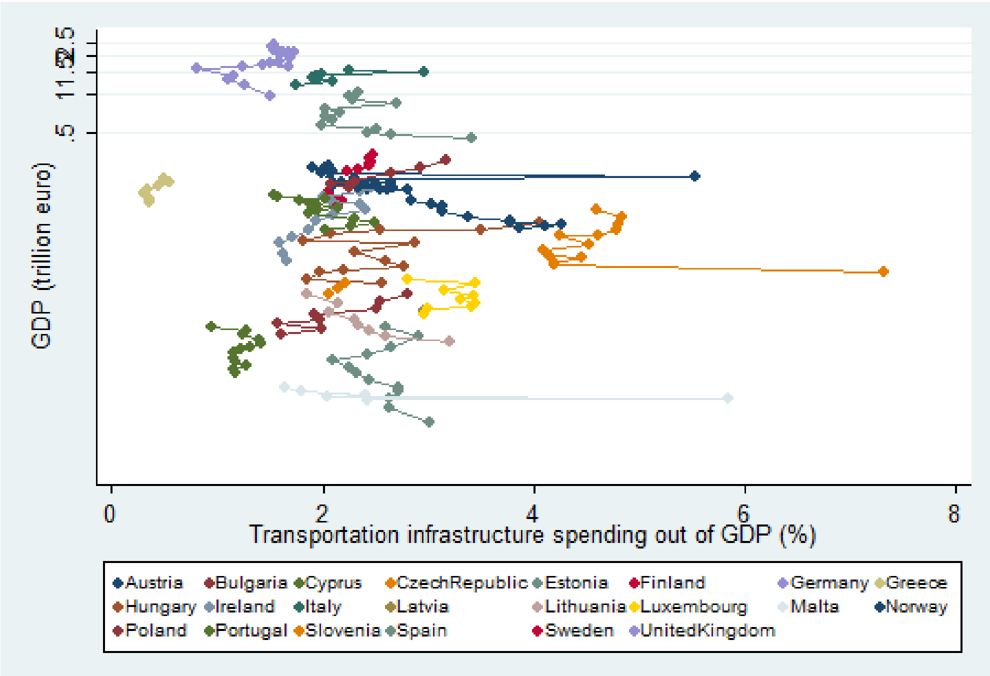

Figure 2: Substitution elasticity and freight rate of construction steel vs. other industries

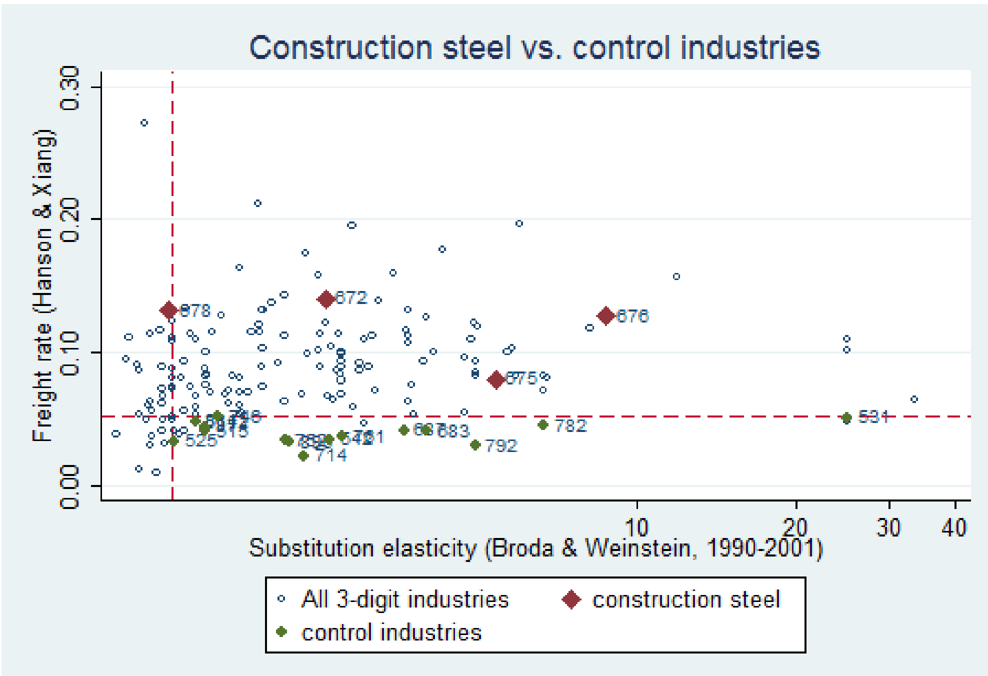

Figure 3: Substitution elasticity and freight rate of construction machinery vs. other industries

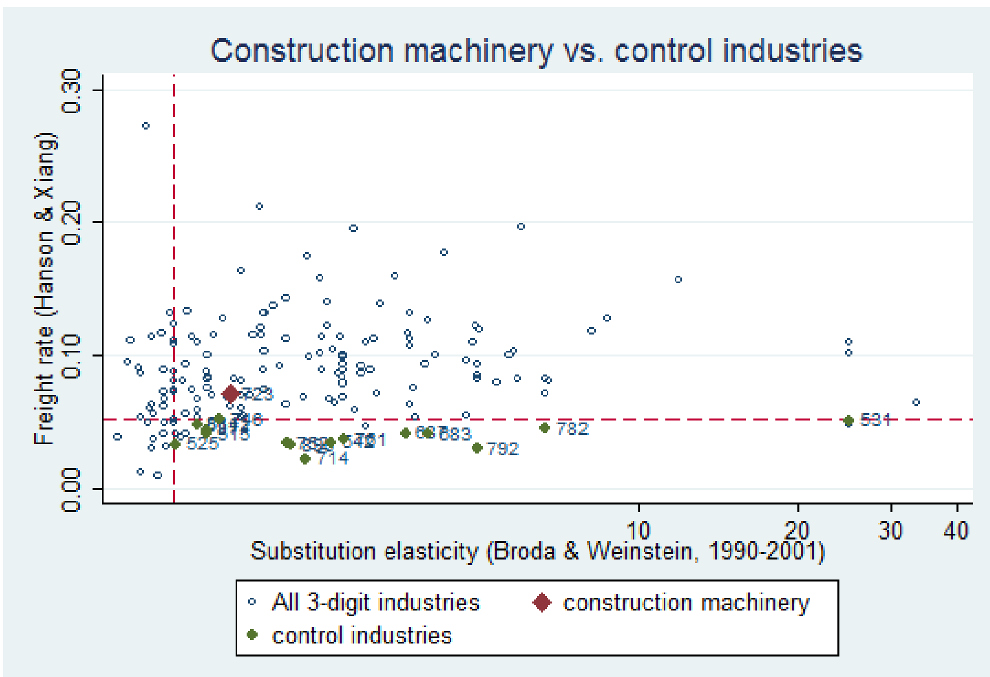

Figure 4: Substitution elasticity and freight rate of cement vs. other industries

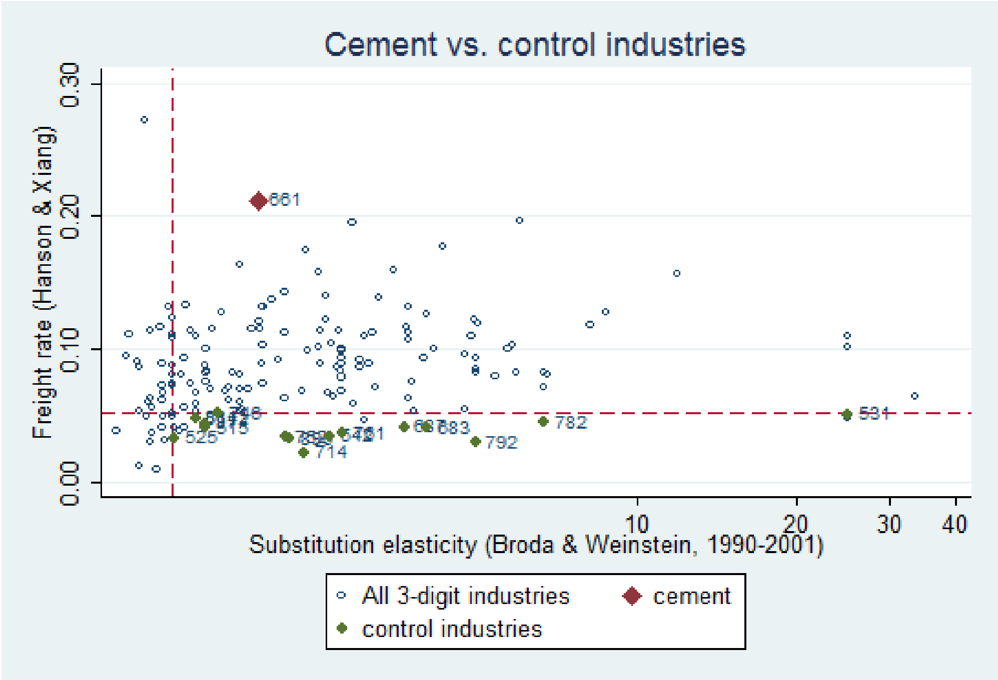

Figure 5: Substitution elasticity and freight rate for all industries

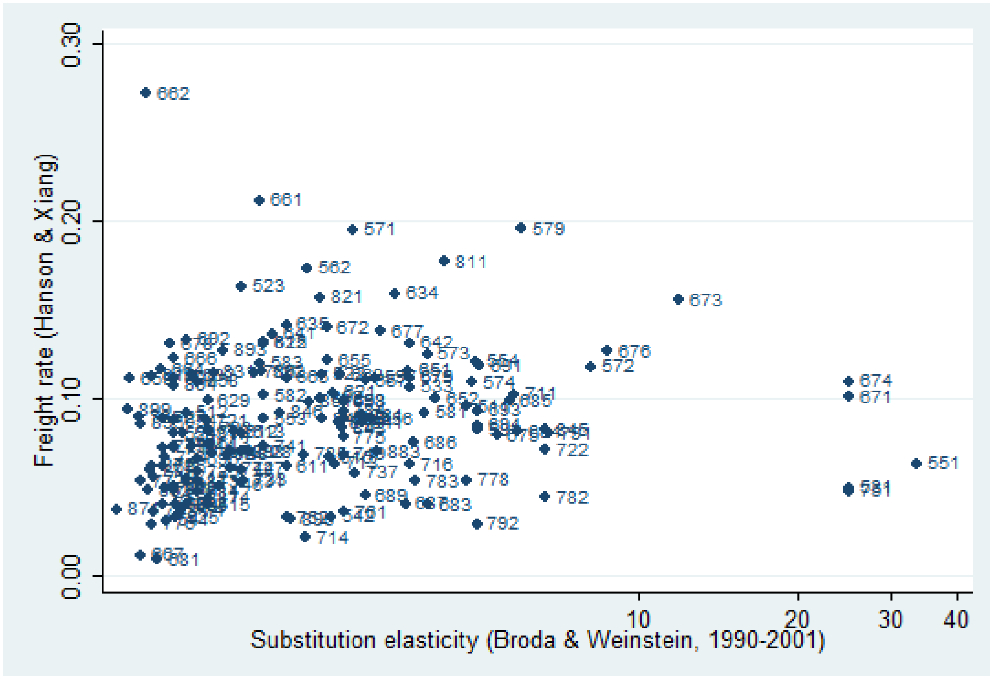

Figure 6: Public spending on housing projects out of GDP vs. GDP

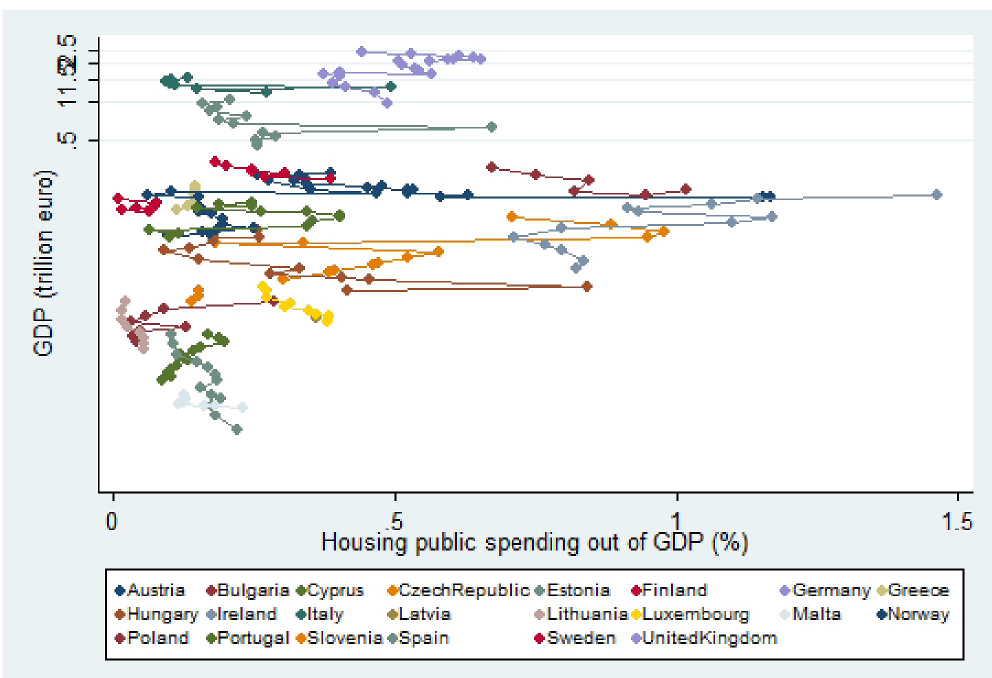

Figure 7: Substitution elasticity and freight rate of glass vs. other industries