Logistics costs and competitiveness: measurement and trade policy applications

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Abstract: This paper examines the issue of measuring logistics costs from an applied trade policy research perspective, as well as identifying logistics-intensive sectors. It focuses on currently available data at the macro- and firm-levels. Data sources considered include national accounts, national input-output tables, the International Comparison Project, firm-level data, and production and trade data. Although current data exhibit a number of weaknesses compared with "custom" logistics costs data—notably in terms of sectoral definition—they nonetheless make it possible to conduct some preliminary empirical analysis that can inform future measurement efforts. First, the paper finds that there is little systematic evidence of a link between the size of the logistics sector and economic outcomes, such as trade openness. Second, the relationship between the size of the logistics sector and logistics performance is non-monotonic. Third, the size of the logistics sector only increases in per capita income up to a certain point, before the relationship turns negative. These findings suggest that measures of sectoral size—such as logistics costs relative to GDP—may be of limited use to researchers and policymakers because they do not have an unambiguous interpretation in terms of performance or economic outcomes. Fourth, however, direct indicators of price and performance are more clearly related to economic outcomes, and have a more straightforward relation with per capita income. The emphasis going forward should therefore be on compiling data that capture logistics performance most accurately, rather than sector size. Finally, the paper uses input-output data to identify logistics-intensive sectors, and finds suggestive evidence that improvements in logistics performance could lead to sectoral reallocations in favor of relatively heavy industries in developing countries, which is consistent with the goal of export diversification.

Keywords: Logistics; Trade policy; Data and measurement.

JEL Codes: L90; F13.

1 Introduction

Despite the commercial importance of the logistics sector in helping firms complete import and export transactions, international trade practitioners have only recently come to focus on it in any detail. There are two main ways in which logistics intersects with the trade policy agenda. First, logistics covers a number of sectors that are subject to ongoing liberalization discussions at regional and multilateral levels in the context of trade in services. Examples include transport and distribution. Some regional initiatives, such as ASEAN, have recognized the importance of logistics by treating it as an independent "cluster" for negotiation and liberalization purposes, even though it cuts across a number of pre-existing sectoral definitions in the ISIC and GATS classifications. There is thus a strong linkage between the logistics sector and trade policy in services.

The second area in which linkages between trade and logistics emerge is in the context of trade facilitation. Although the WTO has adopted a narrow working definition of trade facilitation—focusing essentially on import and export procedures—many other forums, such as APEC, have adopted a much broader approach. More generally, trade facilitation can be considered as including the full range of policies that tend to reduce the transaction costs affecting international movements of goods. Improving logistics performance is in fact at the core of the private sector trade facilitation agenda, and is an important complement to public sector measures such as reducing red tape, and improving infrastructure quantity and quality.

Although there is now an extensive body of analytical work on the links between trade facilitation—using both the broad and narrow definitions—and trade flows, there is as yet relatively little analytical work dealing specifically with the trade effects of logistics sector performance. Until recently, the data constraints involved in doing such work have proved formidable. However, a number of recent initiatives, such as the World Bank's Logistics Performance Index, have started to loosen that constraint.

Against that background, this paper has two main aims. First, it provides a first overview of currently available data relevant to logistics, and suggests some preliminary applications. Although data availability is limited in terms of country coverage and sector specificity, it is useful to analyze freely-available data to see whether expected relationships appear to exist. Examining data in this way can also provide important insights into the types of data that could be collected in the future. Such exercises have not previously been conducted in the literature. Clearly, though, a major caveat in relation to the analysis undertaken here is that it necessarily relies on proxies for the logistics sector, and does not purport to capture the full range of logistics activities considered by more micro-level, industry-specific studies. Nonetheless, there is a tradeoff to be made in terms of data availability versus specificity, and a number of important insights arise from the basic analysis presented here.

The second objective of this paper is to frame the issue of logistics cost measurement and data collection in terms of the types of inputs needed for applied trade policy research. As will be shown, the needs of trade researchers are fundamentally different from those of industry groups: the latter can make use of data that effectively measure sector size for political economy purposes, but trade researchers need to focus more on issues of performance as measured by cost relative to some output price. Once such data become available, however, a number of interesting research avenues are available. On the one hand, logistics performance is expected to be an important determinant of bilateral trade flows, and there is already some empirical evidence to support that view. In addition, logistics performance combined with sectoral logistics intensities can also be expected to have a significant impact on the global pattern of production, exports, and specialization. The cross-sectoral implications of logistics performance have as yet received only cursory attention in the literature, but are likely to be the source of major gains going forward. This paper is the first to sketch out a data-driven research agenda for trade and logistics in this way.

The paper is organized as follows. The next section presents an overview of possible directions in applied trade policy research using logistics data. Section 3 examines existing data sources that can be used to measure domestic logistics costs, focusing on the national accounts, input-output tables, price comparisons, and firm-level data. Section 4 presents a new methodology for measuring international trade costs, and identifies the proportion of those costs due to logistics. Section 5 uses input-output data to identify logistics-intensive sectors in a range of countries. Section 6 concludes.

2 Logistics and Trade Policy Research: What are the Connections?

As noted above, there are a number of connections between logistics and trade policy that have yet to be fully exploited in the literature. One direction in which research could move is to focus on the links between logistics performance and trade intensity (i.e., the intensive margin of trade). Arvis et al. (2007, 2010) present descriptive statistics suggesting a positive association between logistics performance and important outcome indicators, such as trade openness. Hoekman and Nicita (2010) push the analysis further by including the LPI in a gravity model of trade. They find that there is a significant positive association between logistics performance and trade intensity, and that the effect is quantitatively important: increasing the average low income country's LPI score to the middle income average would increase trade by around 15%, which is much stronger than the other reform scenarios considered by the authors, including reductions in traditional trade barriers such as tariffs. Considering logistics as part of the broad trade facilitation agenda, this result sits well with previous work such as Wilson et al. (2005), which consistently finds that the potential gains from improved trade facilitation are significantly larger than those from improvements in traditional market access constraints.

The trade facilitation literature has recently expanded to consider the extensive margin of trade as well, i.e. exporting new products and dealing with new markets. The data strongly suggest that better trade facilitation is linked with a more diversified export bundle in both the sectoral and geographical

dimensions (Dennis and Shepherd, 2011; and Shepherd, 2010). However, there is as yet no specific evidence on the extensive margin trade effects of logistics performance. Future research could examine questions such as whether better logistics make it more likely that production networks can be formed among a range of countries. The policy implications of such research are clear for countries in Asia and elsewhere that are interested in promoting further integration into regional and international production networks.

Most of the studies referred to above focus on total trade flows, and do not deal in depth with issues of cross-sectoral heterogeneity. However, some sectors are likely to be much more intensive in their use of logistics services than others (see further below), which suggests that they may respond more strongly to improvements in performance. Saslavsky and Shepherd (Forthcoming) present some of the first evidence on this point, focusing on the case of parts and components. Since those products are often traded within international production networks that are based on low inventories and just-in-time management, logistics would seem to play a crucial role in facilitating this kind of trade. Indeed, the data suggest that this is the case: trade in parts and components is nearly 50% more sensitive to improvements in logistics performance than is trade in final goods.

There is clearly great scope for future work to examine the issue of cross-sectoral heterogeneity more closely. It is likely, for example, that time sensitive products such as perishable agricultural goods are more sensitive to logistics performance than non-perishable goods; however, there is as yet no evidence on this point. Future work in this area could also follow one strand of the trade facilitation literature in examining not only the potential for logistics performance to boost trade, but its impact on the pattern of sectoral specialization across countries. Djankov et al. (2009), for example, show that countries with low export times tend to be relatively specialized in the export of time-sensitive goods. There is as yet

no comparable evidence for logistics, but similar results could be expected. This line of research would have important policy implications in areas such as competitiveness and export diversification.

An additional area that has only just started to be explored in the trade facilitation literature is the use of firm-level data. In line with the broader trade literature, the use of firm-level data is attractive for two reasons. First, firm-level models do not suffer from omitted variables bias in the country dimension, since those variables are constant across all firms. Omitted local variables can still be an issue, of course, but variance within countries is much less of a problem than variance across countries, which is the issue that plagues standard cross-country regressions. The second advantage of firm-level data is that enables analysts to identify particular causal paths and economic mechanisms more precisely. For instance, although the cross-country evidence on openness and growth is mixed—see Dollar and Kraay (2004) versus Rodriguez and Rodrik (2000)—there is highly consistent and generally accepted evidence that firms in open sectors tend to be more productive and grow faster (Bernard et al., 2007).

There are a number of recent examples of firm-level data being used in the trade facilitation literature. Shepherd (2010) uses firm-level data to show that poorer trade facilitation as measured by longer lead times to export and import is associated with higher reported levels of trade-related corruption, as poor performance gives firms an incentive to flout the rules by paying "speed money". More generally, Dollar et al. (2006) use firm-level data to show that a variety of business environment constraints affect trade performance and integration into international markets. Li and Wilson (2009) similarly show that time to export is an important determinant of firm-level trade behavior.

The possible research directions for trade and logistics discussed in this section are suggestive of a number of priorities for data collection efforts going forward. First, from a trade research point of view, the crucial data element is the relationship between logistics performance and trade costs. The emphasis in collecting data on logistics should therefore be on performance, rather than on alternative

data points such as sector size. Existing work on the logistics sector tends to aggregate total logistics costs and express them relative to some economic baseline, such as GDP. Although this approach is useful in giving an overall idea of the size of the sector, it is not necessarily relevant for doing trade research. The reason is that it does not automatically follow that larger (or smaller) sectors perform better, i.e. provide a given output at lower cost. So although it is useful to track the evolution of logistics costs relative to GDP over time—as initiatives in a number of countries do—it is important not to lose sight of the limited policy-relevant information contained in such estimates. Indeed, this paper shows that the relationship between sector size and performance is non-monotonic in a large sample of countries. Measures such as the LPI do not suffer from this problem, and can easily be used in cross-country regression frameworks.

From a trade research point of view, it is important to distinguish three ways in which logistics costs can be measured or proxied. The first is logistics costs as a percentage of total firm costs (e.g., Pfohl and Straube, 2008). This measure essentially captures logistics intensity: those sectors that have relatively high levels of logistics costs relative to total costs are relatively intensive in logistics services. Logistics intensity is an important concept for two reasons. First, identifying logistics intensive sectors makes it possible to foreshadow the sectoral impacts of improvements in logistics performance: logistics intensive sectors should be more sensitive to performance improvements than other sectors. Second, logistics intensity combined with logistics performance is likely to be an important determinant of the sectoral composition of production and trade across countries. As a country's logistics performance improves, it is likely to become relatively more specialized in the production of goods that are logistics intensive. These issues are discussed further in Section 5 below.

A second alternative is to aggregate expenditures into a measure of total logistics costs, and then to express it relative to some economic aggregate such as GDP (e.g., Bowersox et al., 2005). This approach
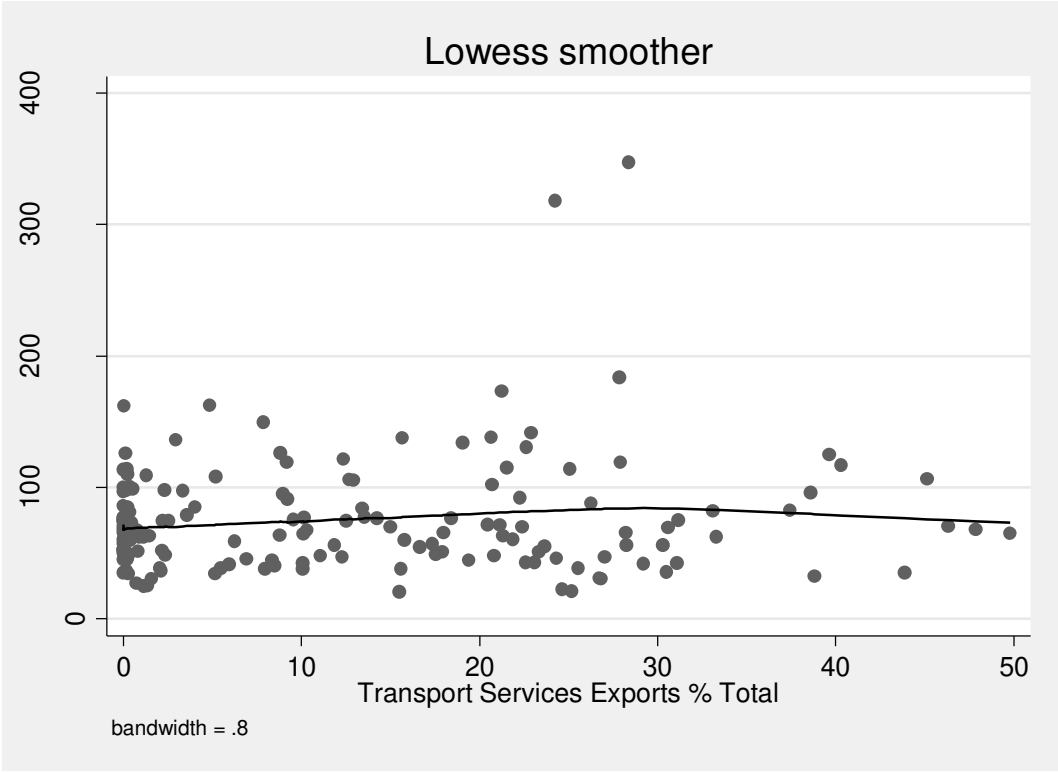
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effectively measures the size of the logistics sector, but does not necessarily indicate anything about performance. Although there is some evidence of a link between the two in the data, the relationship is non-monotonic, which means that it is difficult to draw solid conclusions on performance based only on sector size. See further below, where it is shown that, in general, sector size is not strongly associated with trade outcomes of interest. A further problem with expressing logistics costs relative to GDP is that the final number is likely to be greatly inflated as a true measure of size because intermediate inputs in the logistics sector do not appear to be netted out. That is, total logistics expenditures must equal total logistics sector value added plus the value of all inputs used in the production process. The number is therefore much closer to gross production than value added. Since GDP is the sum of value added in the economy—not gross production—there is strong cause to be skeptical of numbers such as those produced by Bowersox et al. (2005), which indicate that logistics accounts for about 10% of total economic activity in the USA.

The third approach is to proxy logistics costs by using a performance variable, such as the World Bank's Logistics Performance Index (Arvis et al., 2007, 2010). This approach differs fundamentally from the other two in that it does not produce a direct measure of cost. Nonetheless, techniques are available for converting the LPI into a cost-like measure, for instance by calculating total trade costs as an ad valorem equivalent and using econometric methods to identify the part of them that is due to logistics (see Section 4, below). The advantage of a performance measure like the LPI is that it is likely to be strongly linked to trade costs, which are the fundamental variable of interest for applied trade policy work. By contrast, measures such as sector size (logistics costs to GDP ratio) or logistics intensity (logistics costs to total costs ratio) are informative of the characteristics of the sector, but do not have any direct link to trade performance and international economic integration. Another data collection effort that goes in this direction is Hansen and Hovi (2008), in which logistics costs are expressed as a percentage of total export value.

One of the contributions of this paper is to perform a number of external validity exercises using the LPI, and to show that it is correlated with other measures of logistics sector size, performance, and price. Although the focus of the paper is on measurement issues, it is useful to briefly highlight the international trade side of the analysis at this point. As a first step, Figure 1 shows the relationship between merchandise trade openness and specialization in exports of transport services, as a proxy for logistics services. (Due to lack of data availability, it is impossible to measure trade in logistics services as such.) A weak positive association is in evidence until a threshold is reached when transport services exports account for around 30% of the total, after which the relationship flattens out. The data therefore provide some support for the view that specialization in logistics-related services can be important for trade outcomes, though only up to a certain point.
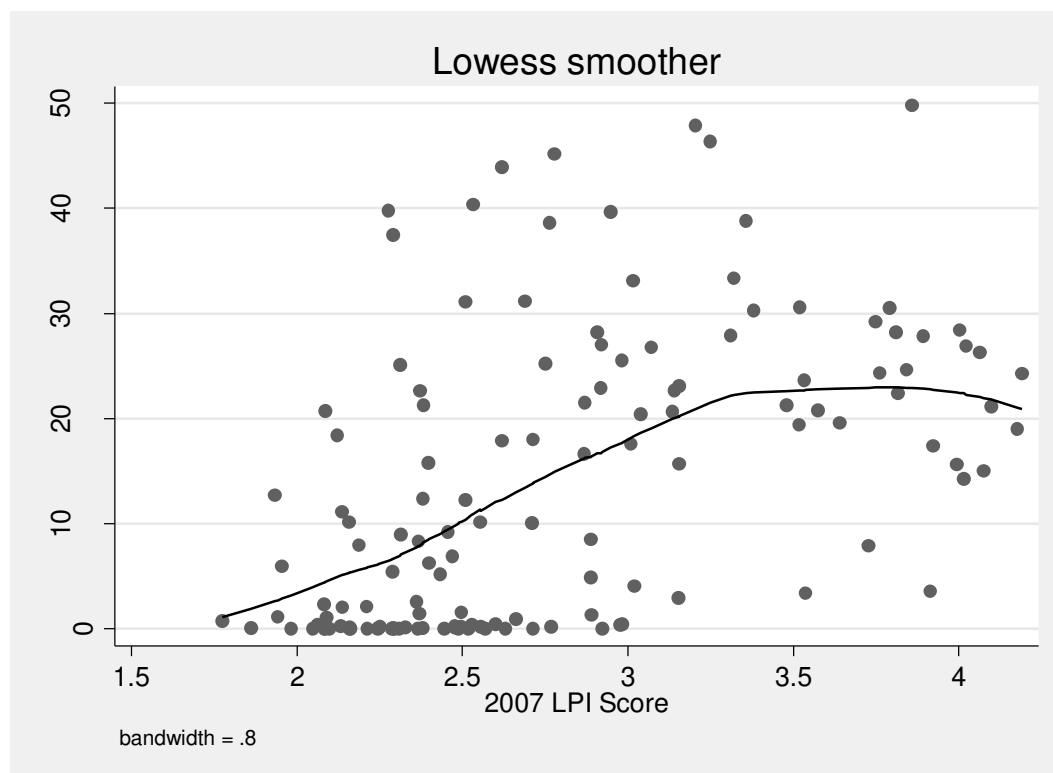
In addition, logistics performance is expected to be associated with trade in services, and in particular with specialization in trade in logistics-related services such as transport. Figure 2 shows that, as expected, countries with stronger logistics performance generally tend to see a higher percentage of their overall services exports accounted for by transport. The effect greatly diminishes, and the relationship thus flattens out, above a certain level of performance (an LPI score of 3.25). Although this result should be interpreted cautiously due to the conventions with which services data are recorded, as well as their relatively poor quality compared with goods trade data, Figure 2 is very much consistent with specialization according to comparative advantage in a logistics-related sector.

Source: Trade in Services Database version 7 (Francois et al., 2009), and the 2007 Logistics Performance Index. Two outliers (Afghanistan and Kyrgyzstan) have been dropped from the sample.

Regardless of which approach is taken to measurement, a key requirement for trade research focusing on logistics is the need for comparable data across a variety of countries and time periods. Cross-country regressions such as the gravity model remain the workhorse of applied international trade research. Similarly, research on the pattern of production and specialization across countries relies heavily on cross-country frameworks. Standardized methodologies and results frameworks for the collection of data on logistics costs are absolutely necessary from a trade research point of view.

Firm-level data on logistics could also be useful for the research agenda going forward. However, they would need to be combined with data on firm characteristics (size, basic financial variables, etc.) and

trade performance (exporters vs. non-exporters, etc.) in order to make it possible to draw policy conclusions. Again, it would be important to focus on measuring logistics performance rather than intensity or sector size.

In the remainder of the paper, the issues discussed in this section are addressed in greater detail in the context of data-based examples during on macro- and firm-level sources.

3   Measuring Domestic Logistics Costs

This section outlines a number of macro-level methodologies that could be used to measure various aspects of domestic logistics costs. The emphasis is on exploiting existing data sources. The first subsection discusses the treatment of logistics in the national accounts, and provides some approximate data on the size of the logistics sector relative to GDP in a number of countries. The second subsection presents data relevant to logistics from the International Comparison Program, focusing on both the size of the sector relative to GDP and prices. The third subsection uses firm-level data from the World Bank's *Enterprise Surveys* dataset to analyze productivity in the logistics sector across a range of countries.

3.1   National Accounts Data

As noted above, recent analysis of the logistics sector has focused on producing aggregate measures of sector size, such as the level of logistics costs relative to GDP. Existing efforts deal with one country at a time, and are difficult to compare across countries because of different methodologies and data sources. An alternative approach that is more easily applied on a cross-country basis is to use national accounts data to obtain an estimate of the size of the logistics sector relative to GDP. Clearly, data obtained in this way will not be directly comparable with work such as that of Bowersox et al. (2005) for two reasons: differences in sectoral classifications mean that what is intended by the term "logistics" will inevitably differ between the two approaches; and the national accounts approach can only

compare the value added by the logistics sector relative to other sectors in the economy, not the total amount spent on logistics, including internal costs, such as inventories. Internal logistics costs can be substantial, especially in low income countries. Nonetheless, national accounts data can provide a useful point of comparison with previous work.

3.1.1 Treatment of Logistics in the National Accounts

Internationally comparable national accounts data follow the International Standard Industrial Classification at a sectoral level. The ISIC system does not identify logistics as a separate sector. However, a number of ISIC Rev.3 sectors are potentially relevant to work on logistics. Table 1 summarizes relevant ISIC Rev.3 sectors according to narrow, medium, and broad definitions of the range of activities included in logistics. The narrow definition of logistics limits the sector to transport and related activities, of which a number in sector 63 fall into the core of logistics services. The medium definition includes in addition wholesale trade, which captures the core of distribution activities. The broad definition also includes retail trade, in order to cover a wider range of distribution activities.

A number of caveats are required in relation to these definitions of logistics. First, as previously noted, they differ somewhat from the commercial definition of logistics activities. The differences go in both directions, i.e. there are some activities that are considered to be part of logistics in the commercial sphere, but which are not included in the ISIC definitions, but at the same time, the ISIC definitions include some activities that are not considered to be logistics from a commercial standpoint. Second, the ISIC definitions are not strictly limited to freight activities, but also include passenger activities within the context of transport. Although it is in principle possible to distinguish between the two by using the three digit level of the ISIC scheme, the cross-country data source used here includes two digit sector definitions only. It is therefore left to future research to return to national sources and develop

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logistics indicators using ISIC three digit data. The results presented here should be interpreted as rough

orders of magnitude only.

ISIC Rev.3 Sector	Narrow Definition	Medium Definition	Broad Definition
60-62: Land, water, and air transport.	✓	✓	✓
63: Supporting and auxiliary transport activities (cargo handling; storage and warehousing; supporting transport activities; travel, tour, and transport agencies).	✓	✓	✓
51: Wholesale trade.		✓	✓
52: Retail trade.			✓

Most countries currently use the ISIC Rev.3 classification for their national accounts. In 2008, a new ISIC

Rev.4 classification was released, but it has not yet been widely implemented. It adopts a generally

similar approach to the sectors of most interest here, the only significant differences being in the

replacement of "supporting and auxiliary transport activities" with "warehousing and support activities

for transportation". The new sectoral definition focuses more closely on core logistics activities, such as

freight forwarding—the word "logistics" is even used in the explanation of class 5229—and excludes

tour and transport agencies. As a result, measurement of logistics activities using national accounts data

can be expected to improve marginally in the coming years with implementation of the ISIC Rev.4

scheme.

3.1.2   Cross-Country Comparison of Logistics Sectors

In principle, national accounts data with some level of sectoral disaggregation are available for a wide

range of countries from local sources. To give a first idea of the type of analysis that could be conducted

using national accounts data, however, it makes sense to look first at data that have already been

cleaned and harmonized by an international agency. The OECD's STAN database provides such data for

OECD members (national accounts by sector), and a number of non-members (input-output tables).

Both sources provide information on value added by sector, which can then be compared with total value added in the economy (GDP). Although there are some discrepancies between the national accounts and input-output tables, they are generally small, and data from the two sources remain relatively comparable. The major difference between the two is that the national accounts data are more disaggregated, which enables application of all three potential ISIC Rev.3 definitions of logistics, as discussed above. The input-output tables, by contrast, are only detailed enough to make it possible to distinguish between the narrow and broad definitions.

Table 2 presents logistics sector data from the STAN database, covering 45 countries (latest year). OECD members account for 34 observations, with the remaining 11 coming from non-member countries including the BRICs, Indonesia, and South Africa. Applying the narrow definition of logistics suggests that the sector accounts on average for about 5% of GDP, although the range is quite large across the countries included in the sample (2%-12%). The medium definition increases the estimated size of the sector substantially, to an average of 11% of GDP. Application of the broad definition results in another substantial increase, to around 17% of GDP on average. Comparing these three sets of numbers with existing work on logistics costs as a percentage of GDP tends to suggest that the medium and broad definitions may include too many non-logistics activities, thereby resulting in substantial over-estimates of the size of the sector. Numbers based on a narrow definition tend to accord better with existing work, particularly taking into account the fact that the data presented here are based on value added (netting out intermediate inputs) rather than gross production (the equivalent of total logistics costs). As a rule of thumb, if the numbers presented here are measuring the same activities as in existing measurements of logistics costs relative to GDP, they should be one-third to one-half as large as previous estimates due to the intermediate inputs problem.

Table 2: Logistics sector value added as a percentage of GDP; alternative definitions.

Country	Year	Narrow	Medium	Broad	Source
Argentina	1997	5.61		17.78	Input-Output
Australia	2006	5.19			National Accounts
Austria	2009	4.20	10.68	15.23	National Accounts
Belgium	2008	5.89	12.81	17.04	National Accounts
Brazil	2005	4.96		18.74	Input-Output
Canada	2005	4.06	9.36		National Accounts
Chile	2003	7.42		16.66	Input-Output
China	2005	5.68		12.50	Input-Output
Czech Republic	2009	7.72	13.19	17.69	National Accounts
Denmark	2009	4.32	11.18	14.63	National Accounts
Estonia	2008	7.53	14.72	19.48	National Accounts
Finland	2009	5.94	10.54	14.18	National Accounts
France	2008	4.41	8.72	12.79	National Accounts
Germany	2008	3.96	8.86	12.72	National Accounts
Greece	2008	6.72	16.34	22.88	National Accounts
Hungary	2007	5.08	10.43	15.12	National Accounts
Iceland	2008	4.62	10.00	14.46	National Accounts
India	2003/04	6.42		18.52	Input-Output
Indonesia	2005	4.18		15.72	Input-Output
Ireland	1995	3.00			National Accounts
Israel	2008	4.19	8.63	11.63	National Accounts
Italy	2009	5.28	10.18	14.38	National Accounts
Japan	2006	4.39	13.22	17.47	National Accounts
Korea	2008	4.38			National Accounts
Luxembourg	2009	4.19	10.84	14.28	National Accounts
Mexico	2008	6.53	22.08	22.65	National Accounts
Netherlands	2008	4.40	12.27	15.49	National Accounts
New Zealand	2006	4.25			National Accounts
Norway	2008	5.00	9.91	12.81	National Accounts
Poland	2007	4.79	11.85	18.82	National Accounts
Portugal	2006	4.01	9.29	13.61	National Accounts
Romania	2005	8.21		19.24	Input-Output
Russia	2000	8.96		39.51	Input-Output
Slovakia	2009	4.66	12.81	19.26	National Accounts
Slovenia	2009	4.84	10.70	15.35	National Accounts
South Africa	2005	5.59		18.57	Input-Output
Spain	2008	4.54	8.74	13.45	National Accounts
Sweden	2008	5.67	11.28	15.01	National Accounts
Switzerland	2008	3.55	10.88	15.69	National Accounts
Taiwan	2006	3.16		25.10	Input-Output
Thailand	2005	4.28		27.93	Input-Output
Turkey	2002	12.26		26.15	Input-Output

UK	2007	4.36	8.27	13.43	National Accounts
USA	2007	2.95			National Accounts
Vietnam	2000	2.21		12.93	Input-Output

Source: OECD STAN database and input-output tables.

The OECD STAN data can be combined with information on other economic variables to provide a first indication of the possible links between the size of the logistics sector and important outcomes of interest. To ensure maximum data coverage, I use the narrow definition of logistics in all cases. To allow for maximum flexibility in examining the possible relationships among variables, I use a non-parametric regression technique—the Locally Weighted Scatterplot Smoother (Lowess)—rather than the more standard parametric OLS approach. Lowess proceeds by conducting a separate OLS regression using each data point as the center of a reduced sample (80% of the full sample), and estimating response parameters for each regression function.

The first question of interest is whether the size of the logistics sector as measured by its weight in GDP is systematically associated with logistics performance, as measured by the World Bank's Logistics Performance Index. Data for the most recent year of the LPI are used (2010), even though the GDP data correspond to a variety of previous years. Due to data limitations, it is impossible to achieve an exact correspondence, which means that results should be interpreted cautiously. Nonetheless, Figure 3 shows a clear negative relation between the size of the logistics sector and performance: the larger the logistics sector, the worse is performance, on average. The reason is likely linked to technological change: as technology improves, it becomes possible to achieve a given level of service for a lesser amount of expenditure. Offsetting this effect is increased demand for logistics services as the price falls (or quality rises), but these data suggest that it is the technological improvement effect that dominates, at least in the limited country sample used in this first analysis (mostly OECD members).
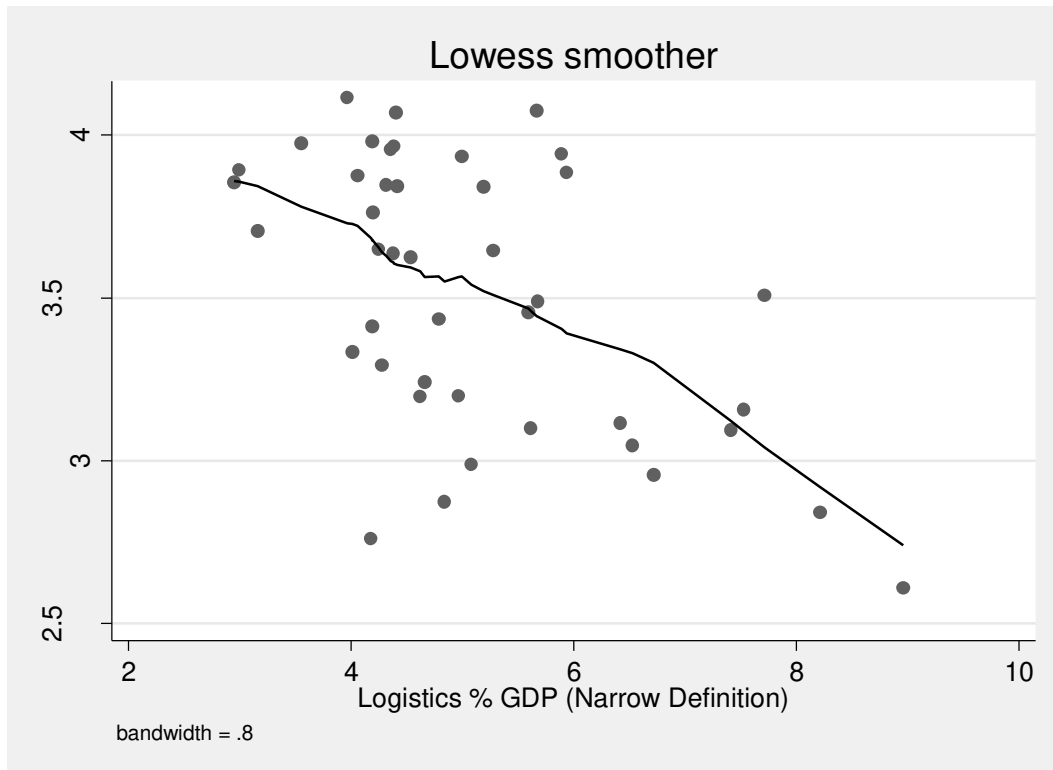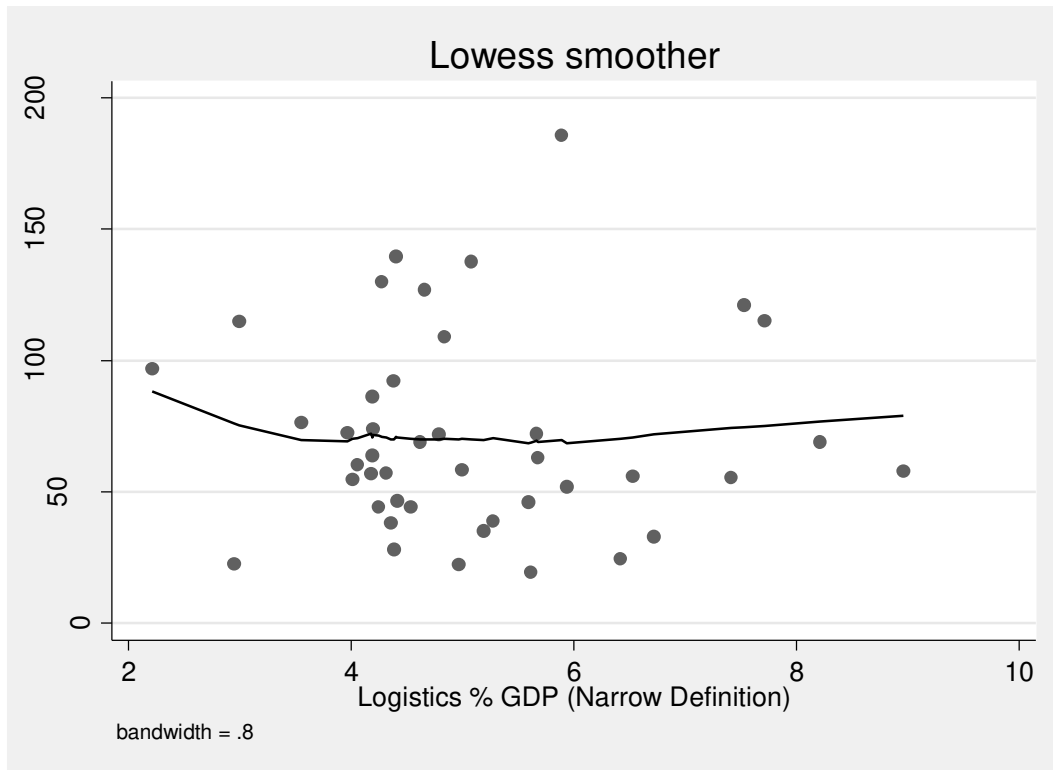
Note: Data sourced from the OECD STAN database and input-output tables (logistics data), and the 2010 Logistics Performance Index. Two outliers (Vietnam and Turkey) have been excluded from the sample.

In light of the apparently strong link between sector size and performance in these data, it is surprising that an important economic variable of interest—trade openness, defined as the sum of merchandise exports and imports relative to GDP—does not appear to have any strong association with sector size.

Figure 4 shows that there is little evidence of a systematic relationship between openness and the size of the logistics sector: the regression line is essentially flat throughout most of the sample. For example, there is no systematic evidence that countries with larger logistics sectors tend to be more open to international trade. The reason for this finding is perhaps that openness is dependent on a wide range of factors, of which logistics performance is only one. Since sector size is really being used here as a proxy for performance, the link between the two tends to be weakened, in this case to the point of insignificance.
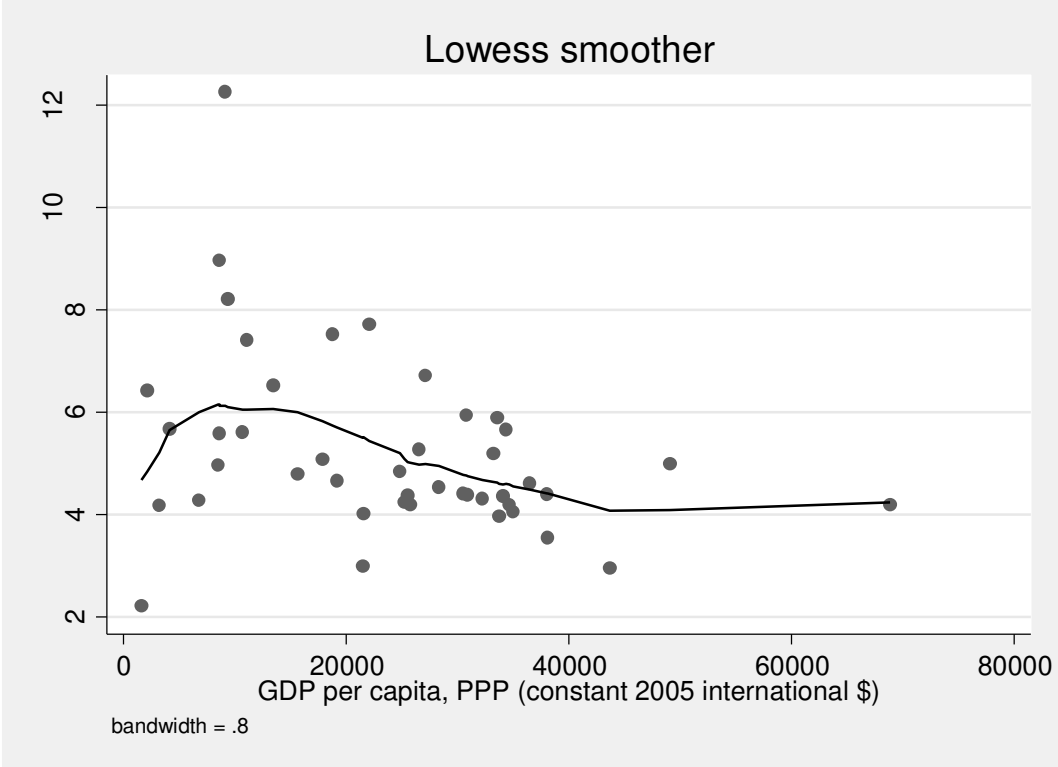
Note: Data sourced from the OECD STAN database and input-output tables (logistics data), and the World Development Indicators (openness). One outlier (Turkey) has been excluded from the sample.

A third hypothesis of interest concerns the relationship between per capita income and the size of the logistics sector. It might be thought, for example, that richer countries tend to have larger logistics sectors. One reason for this effect might be that outsourcing takes place at a greater rate as countries develop. Figure 5 provides a much more nuanced picture, however. There is indeed a positive relationship between sector size and per capita income in relatively poor countries, but an inflection point is reached at around $10,000 in PPP terms. Once country income exceeds the level of, for example, Argentina or Mexico, there is an inverse relation with the size of the logistics sector. One possible explanation is that improvements in technology in upper-middle- and high-income countries tend to dominate increased demand for outsourced logistics services. However, this is a point that would need to be researched in more detail in the future. For the present, it is simply important to note

that richer countries do not systematically have a larger logistics sector. This finding is indeed consistent

with the first one, to the effect that a larger sector tends to be correlated with worse performance.

Figure 5: Non-parametric regression of the size of the logistics sector (narrow definition) on per capita income.

Note: Data sourced from the OECD STAN database and input-output tables (logistics data), and the World Development Indicators (per capita income).
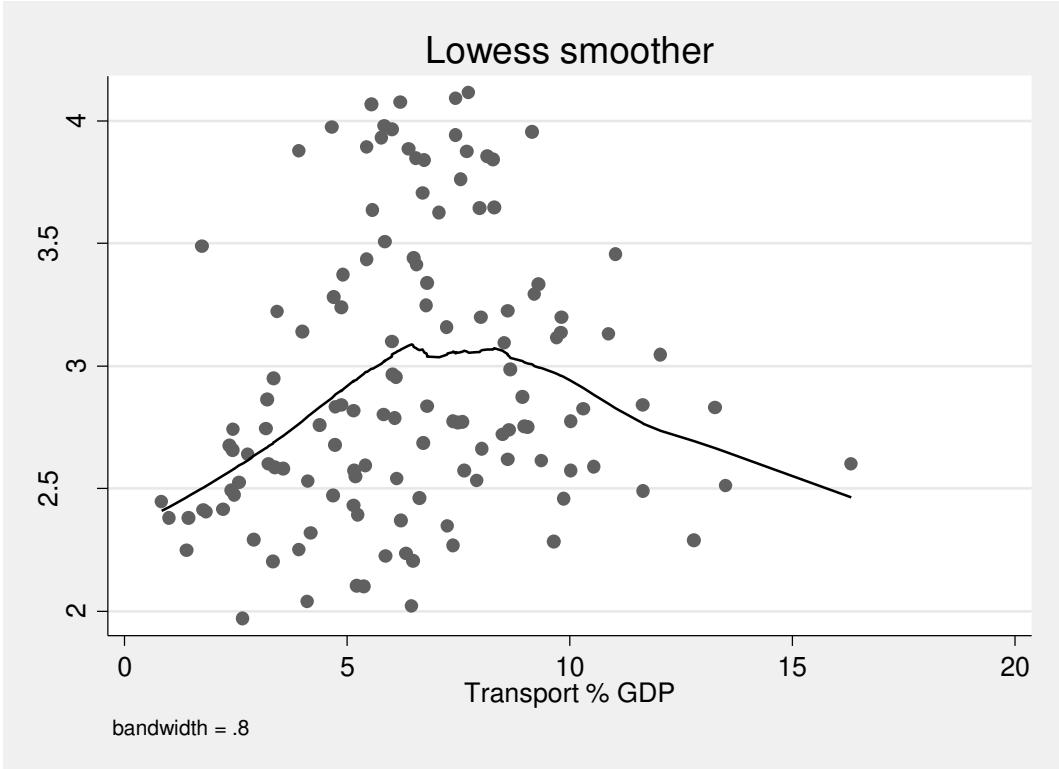
3.2   The International Comparison Program

Another useful data source for conducting cross-country analysis in relation to the logistics sector is the

International Comparison Program (ICP). The ICP is a worldwide statistical partnership to collect

comparative price data and compile detailed expenditure values of countries' GDPs, and to estimate

purchasing power parities (PPPs) of the world's economies. Although the ICP does not identify logistics

as a separate sector, it does provide data on the size of the transport sector and the level of transport

prices in 155 countries. These measures can be taken as rough proxies for the size of the logistics sector

and its price level, on the assumption that transport activities represent an important part of the overall

concept of logistics. Again, results need to be interpreted cautiously due to the difference between this sectoral definition and the understanding of logistics that is common in the sector-specific literature.

Figure 6 repeats the analysis in Figure 3 above, namely the relationship between sector size and logistics performance as measured by the World Bank's LPI 2010. The connection between the two variables is more nuanced than in the smaller sample—primarily composed of OECD members—considered above, using national accounts data. In this case, there is a positive relationship between sector size and performance up to a certain point—around 7% or 8% of GDP—after which it turns negative. Increasing the size of a very small transport sector therefore tends to be associated at the margin with improved logistics performance, but above a critical point, performance improvements tend to be associated with decreases in sector size. The two figures can be reconciled by noting that the restricted sample considered in Figure 3 generally has strong logistics performance, so the regression line only captures the right hand part of the full-sample regression curve in Figure 6.

Lowess smoother

bandwidth = .8

Note: Data sourced from the International Comparison Program (transport data), and the 2010 Logistics Performance Index.

Again, attempting to extend the analysis to trade openness gives poor results, despite the link—albeit non-monotonic—between sector size and logistics performance (Figure 7). As was the case using national accounts data, there is no systematic relationship between the size of the transport sector and the level of openness to the international economy: countries with larger transport sectors are not systematically more open.
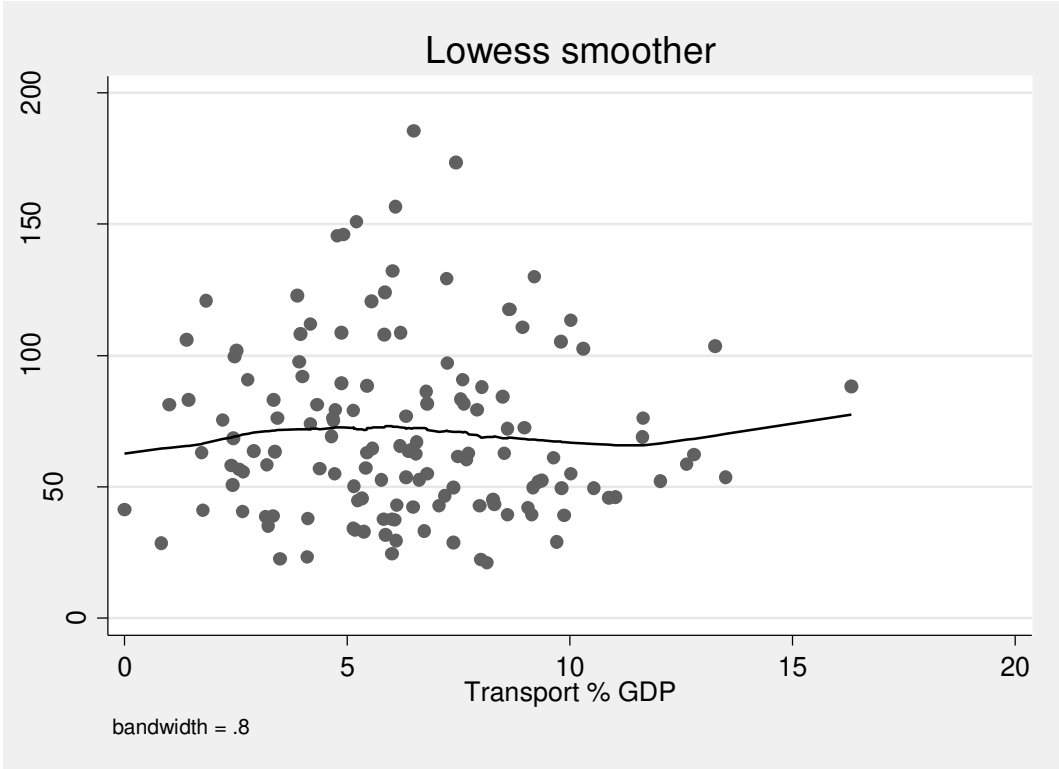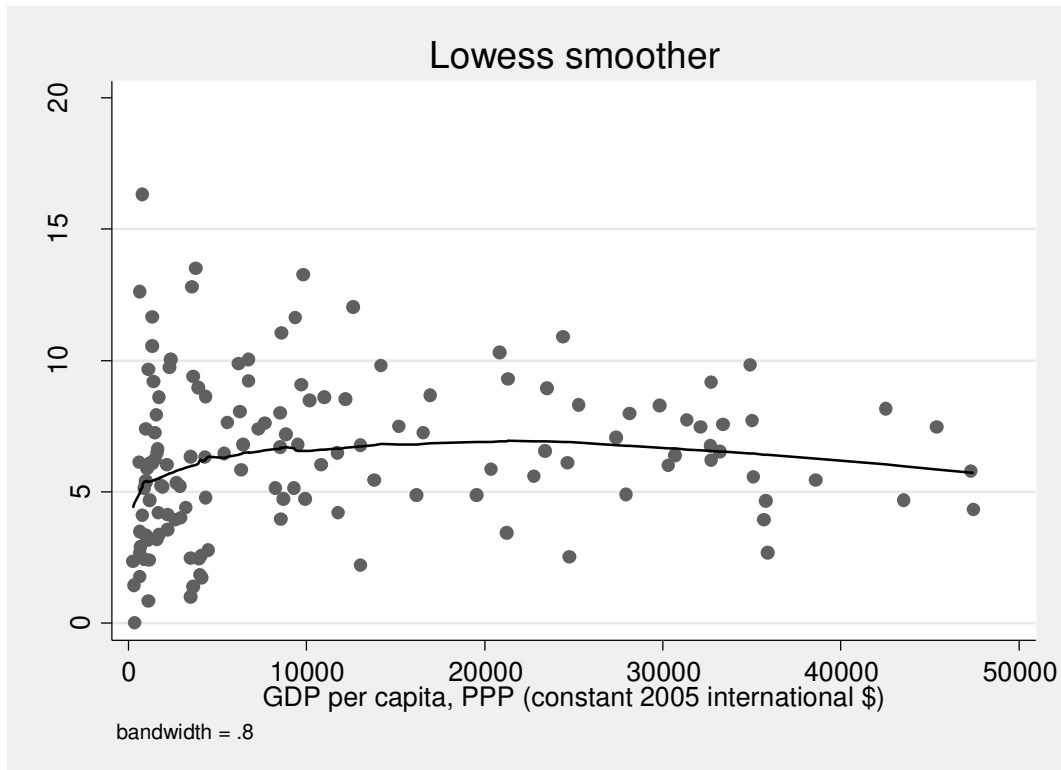
Note: Data sourced from the International Comparison Program (transport data), and the World Development Indicators (trade openness). Two outliers (Hong Kong, China and Singapore) have been excluded from the sample.

The ICP data can also be used to analyze the relationship between the size of the transport sector and per capita income. As was the case for the national accounts data, Figure 8 shows that the relationship is non-monotonic: richer countries tend to have larger transport sectors until an income level of around $20,000 is reached, at which point the transport sector appears to contract. The inflection point is considerably higher than in the national accounts—at around the income level of Portugal or Greece—but the same general relationship between the two variables is apparent.
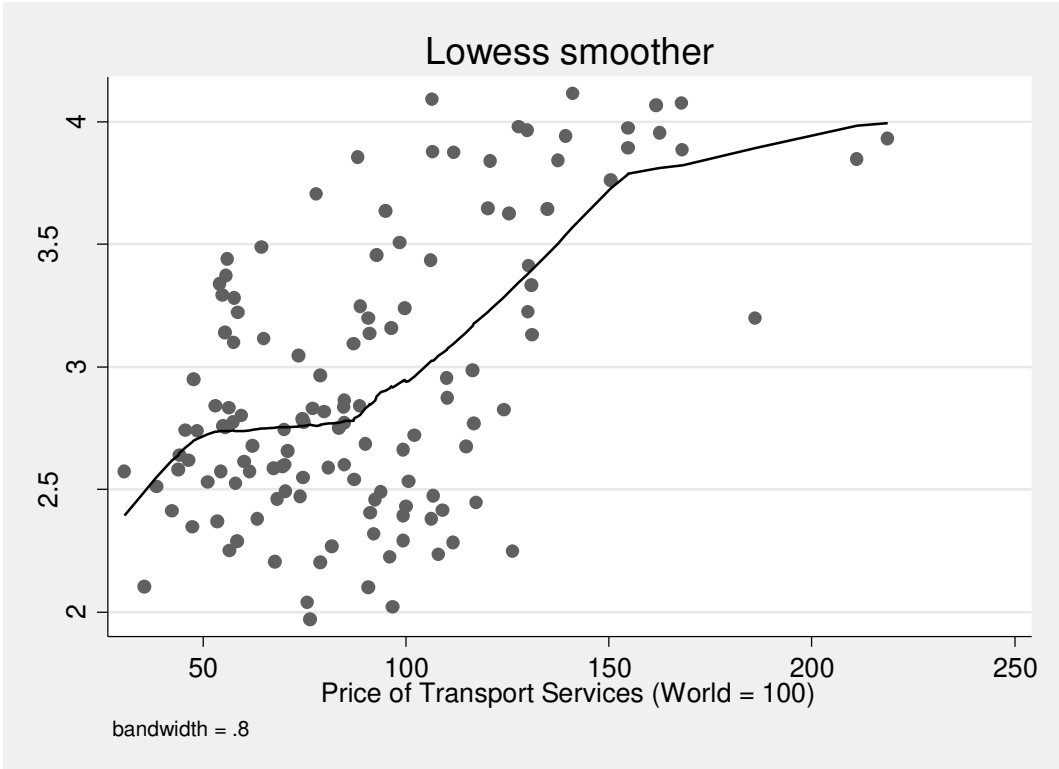
Note: Data sourced from the International Comparison Program (GDP data), and the World Development Indicators (per capita income). Two outliers (Luxembourg and Qatar) have been excluded from the sample.

In addition to sector size, the ICP dataset also provides information on prices in the form of an index number (world = 100). Figure 9 examines the relationship between transport prices and logistics performance. Interestingly, there is a strong, positive relationship: higher prices are generally associated with stronger performance. At first, this result might appear surprising because technological improvements linked to superior performance can sometimes drive prices lower, not higher. However, there are a number of economic mechanisms at play to explain the positive relationship seen in these data. First, the Balassa-Samuelson effect suggests that prices are generally higher in more developed economies, which also tend to have stronger logistics performance. The figure is partly capturing this relationship. Second, high prices and high performance might be indicative of the fact that end users of logistics services are prepared to pay a premium for good, reliable service. Technology improvements

that increase service level but also costs might therefore still be attractive to end users optimizing their supply chain performance.

Figure 9: Non-parametric regression of logistics performance on the price of transport services.
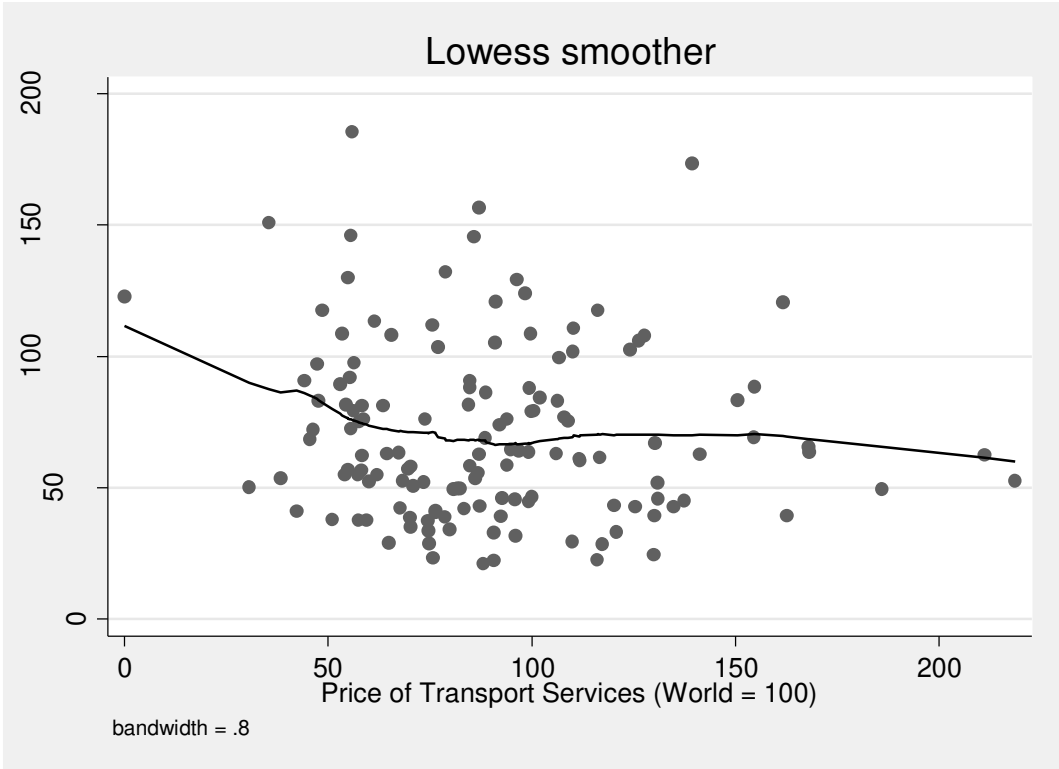

Note: Data sourced from the International Comparison Program (price data), and the Logistics Performance Index 2010.

Figure 10 examines the relationship between transport sector prices and trade openness. Although the regression line is relatively flat through much of the sample—which is suggestive of a weak, and possibly insignificant relationship—there is some evidence of an overall negative relationship between the two variables: countries with higher transport prices tend to be less open to the world economy, particularly at relatively low levels of transport costs. As transport costs increase above a threshold—roughly the world average—the negative relationship more or less disappears. The first finding is in line with expectations, but its contingent nature highlights the fact that countries with very high levels of transport costs need to make significant improvements before major changes in economic outcomes

will be apparent. The need for a "big push" in this area has similarly been recognized in recent work on logistics performance (Arvis et al., 2010).

Figure 10: Non-parametric regression of trade openness on the price of transport services.
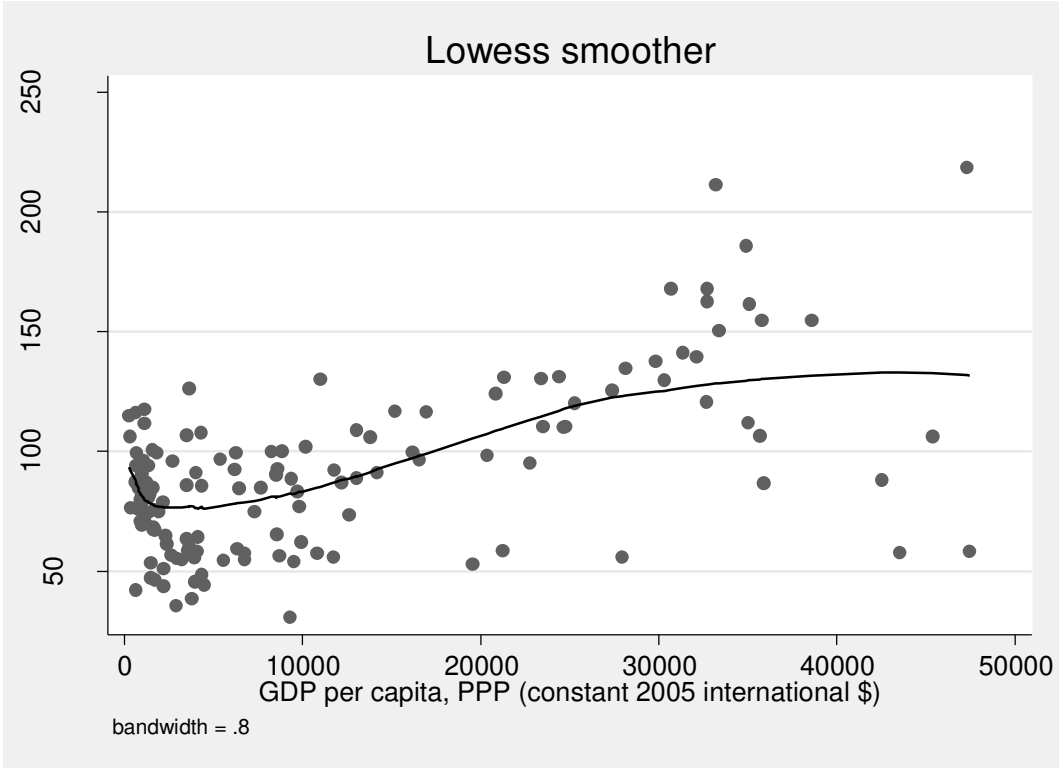

Note: Data sourced from the International Comparison Program (price data), and the World Development Indicators (trade openness). Two outliers (Hong Kong, China and Singapore) have been excluded from the sample.

Finally, Figure 11 examines the relationship between transport prices and GDP per capita. Although the regression suggests a non-linear relationship—particularly at very low levels of income—the overall relationship is positive: richer countries tend to have more expensive transport services. As noted above, a number of factors could support such a conclusion. First, transport services obviously involve a higher level of technological inputs in high-income countries than in low-income ones. Higher prices would thus reflect the provision of a different level of service. Second, this finding might be a manifestation of the much more general Balassa-Samuelson effect, due to the fact that the bulk of transport services take place within a country and thus are not traded internationally in the

conventional sense. Such trade can take place via GATS Mode III (commercial presence), but the economic mechanisms involved are quite different. In light of these sorts of mechanisms, it is not surprising that logistics performance but also prices should be higher in more developed economies.

Note: Data sourced from the International Comparison Program (price data), and the World Development Indicators (per capita income). Two outliers (Luxembourg and Qatar) have been excluded from the sample.

As an additional exercise, ICP data were also used in an attempt to test the hypothesis that logistics performance can be an important determinant of price gaps across countries. Price data in sectors such as food products and clothing were used as the dependent variable, with logistics performance proxied by the LPI as the independent variable. Results, however, were not in line with expectations: higher prices were consistently associated with higher LPI scores. The most likely explanation for this finding is that prices (due to the Balassa-Samuelson effect) and logistics performance are both strongly positively correlated with per capita income. The regressions therefore just pick up the association between

development level and logistics performance, rather than saying anything specific about price differences across countries. For this reason, results are not discussed in detail at this point. The potential impact of logistics on price gaps is left as an issue for future research to examine using more detailed data.

3.3 Firm-Level Data

The recent international trade literature has become heavily focused on firm-level phenomena (see Bernard et al., 2007 for a review). Although most firm-level work in international trade focuses on a single country, the World Bank's Enterprise Surveys dataset makes it possible to do cross-country work at the firm-level as well. As Table 3 shows, the 2001-2005 Enterprise Surveys dataset covers services as well as manufacturing, and has at least some observations on firms active in logistics-related sectors such as wholesale and retail trade, and transport. The sectoral coverage of the Enterprise Surveys data essentially mirrors the broad definition of logistics used in the analysis of national accounts (see above). For this reason, caution is again required in interpreting results due to differences in sectoral definitions between the national accounts and commercial reality, in particular as regards the inclusion of passenger services in the definition of transport.

Table 3: Availability of Enterprise Surveys firm-level data (2001-2005).

Sector	Number of Countries	Total Observations
Wholesale and Retail Trade (51-52)	98	10,188
Transport (60-63)	70	1,456

The primary interest in firm-level data as a descriptive tool lies in the possibility of estimating firm- and sector-level productivity for logistics providers. These measures can in principle provide detailed information on sector performance. As an example, I calculate simple labor productivity measures using the *Enterprise Surveys* data referred to in Table 3; attempts to estimate total factor productivity using

the Levinsohn-Petrin methodology ran into numerical difficulties, and will need to be left for future research. To enable cross-country comparisons, I average the labor productivity estimates by country.
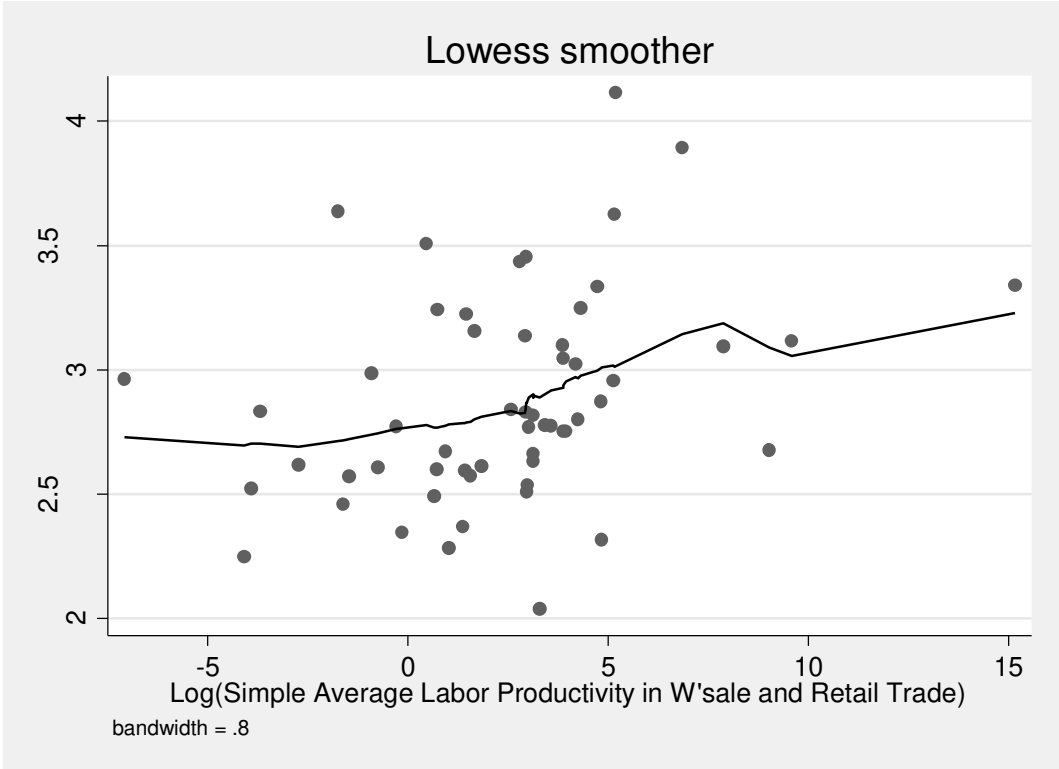
Figure 12 presents a non-parametric regression of logistics performance, as measured by the LPI, and labor productivity in the transport sector as captured in the *Enterprise Surveys* data. Although the sample is relatively small, there is a clear positive association between transport productivity and logistics performance: countries with more productive transport sectors tend to have higher overall logistics performance. Figure 13 repeats the analysis using productivity in wholesale and retail trade as the independent variable, with similar results. Although the relationship is weaker, there is still a noticeable positive association between productivity and logistics performance. The difference in strength between the associations evident in Figures 12 and 13 is perhaps due to the fact that transport plays a larger role in what is commonly referred to as the logistics sector than do wholesale and retail trade activities.

Figure 12: Non-parametric regression of logistics performance on labor productivity in transport.
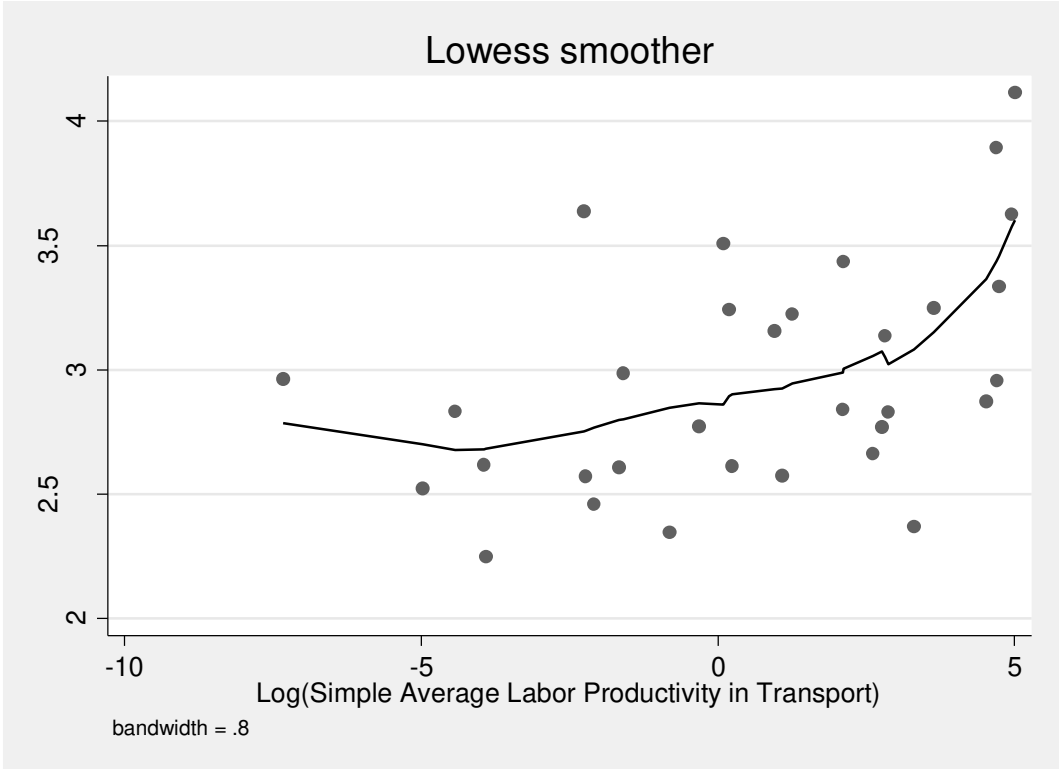
Note: Data sourced from Enterprise Surveys (productivity data), and the Logistics Performance Index 2010. One outlier (Lebanon) has been excluded from the sample.

Note: Data sourced from Enterprise Surveys (productivity data), and the Logistics Performance Index 2010.

Figure 14 presents results of a non-parametric regression of labor productivity in transport on GDP per capita. Figure 15 repeats the regression using labor productivity in wholesale and retail trade, rather than transport. Results in both cases are in line with expectations: countries at higher income levels tend to have more productive logistics sectors. As was the case for the LPI as dependent variable, the relationship appears to be stronger for the transport sector than for wholesale and retail trade.

Figure 14: Non-parametric regression of labor productivity in transport on per capita income.
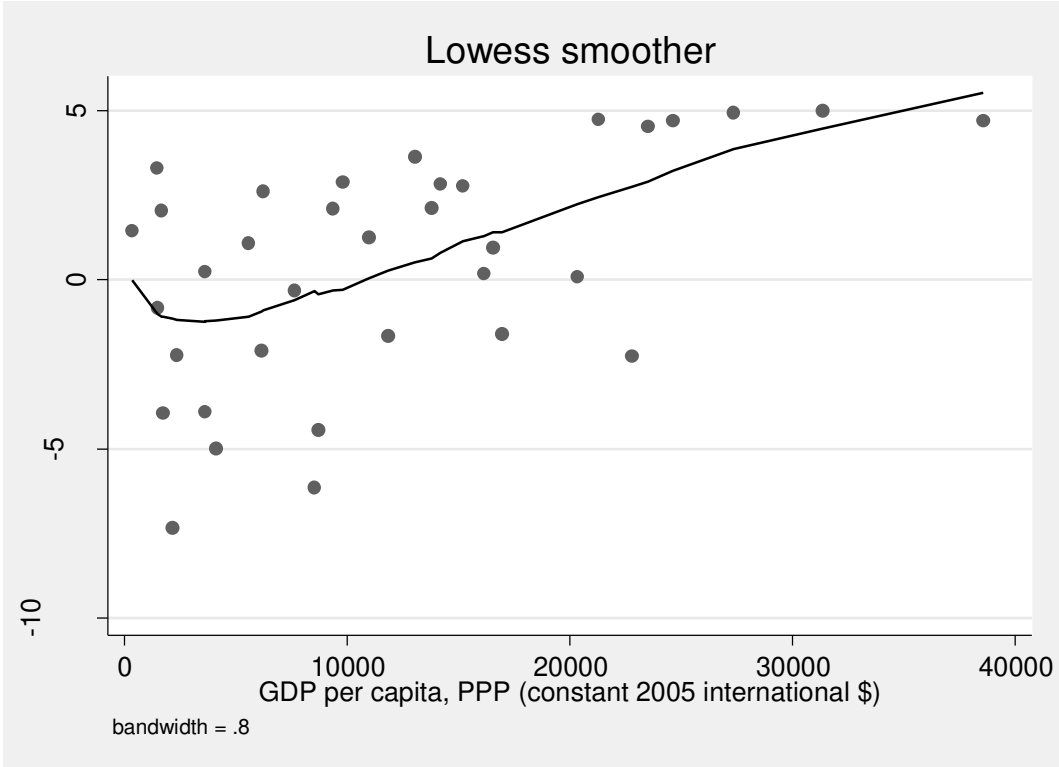
Note: Data sourced from Enterprise Surveys (productivity data), and the World Development Indicators (per capita income). One outlier (Lebanon) has been excluded from the sample.

Figure 15: Non-parametric regression of labor productivity in wholesale and retail trade on per capita income.
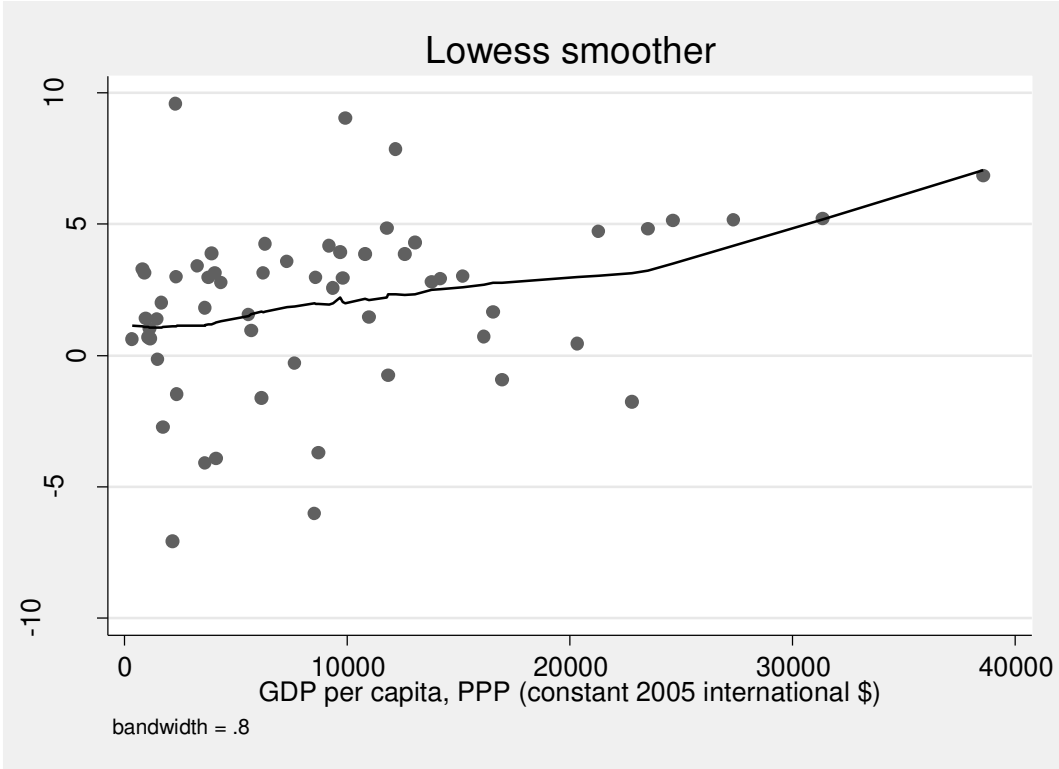
Note: Data sourced from Enterprise Surveys (productivity data), and the World Development Indicators (per capita income). One outlier (Lebanon) has been excluded from the sample.

More surprising are results in Figures 16 and 17, where the dependent variable is trade openness. In both cases, the data suggest that higher productivity in logistics is associated with a lesser degree of openness, which is contrary to expectations. The reasons for this result are as yet unclear. One possibility is that labor productivity is only a very approximate measure, and that results using total factor productivity might be different. Another possibility is that the data are primarily capturing the characteristics of domestic logistics firms, not those involved directly in international transactions. Presumably, productivity in international logistics operations would be positively associated with openness. However, these questions will need to be examined further in future research.

Note: Data sourced from Enterprise Surveys (productivity data), and the World Development Indicators (openness). One outlier (Lebanon) has been excluded from the sample.

Figure 17: Non-parametric regression of trade openness on labor productivity in wholesale and retail trade.

Note: Data sourced from Enterprise Surveys (productivity data), and the World Development Indicators (openness). One outlier (Lebanon) has been excluded from the sample.
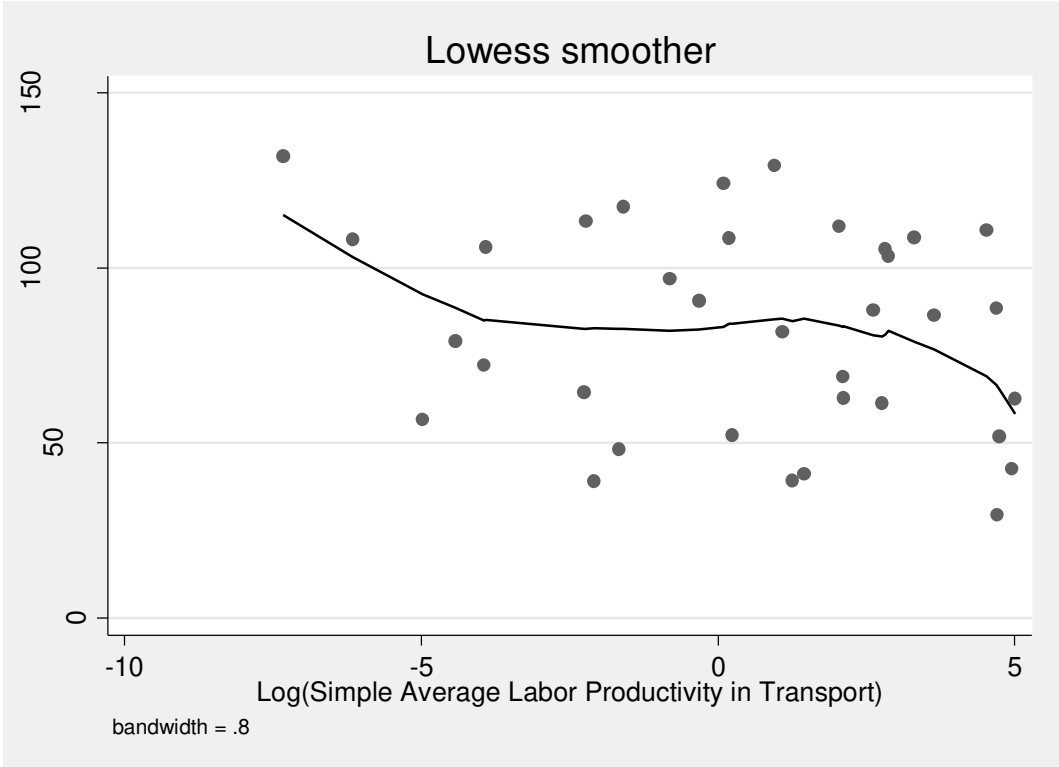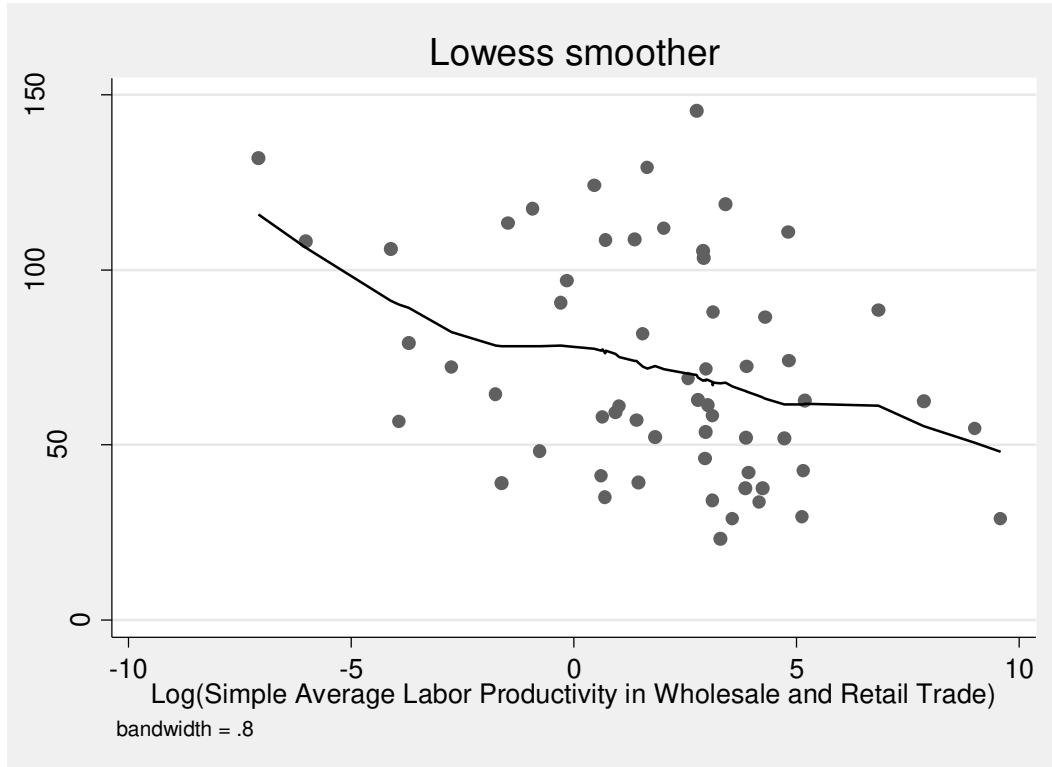
The above analysis has only exploited one part of the *Enterprise Surveys* dataset, namely surveys undertaken between 2001 and 2005. Future research can exploit similar data from later surveys (Table 4). These new data offer the advantage of being disaggregated according to a more precise sectoral definition following the ISIC scheme. It will therefore be possible to examine the relationship between productivity in individual components of the logistics sector, and important economic outcomes, as well as overall logistics performance.

Table 4: Availability of Enterprise Surveys firm-level data (2006-2010).

Sector	Number of Countries	Total Observations
Wholesale Trade (51)	72	1,964
Retail Trade (52)	104	8,867
Land Transport (60)	65	600
Water Transport (61)	16	40
Air Transport (62)	24	35

4   Measuring International Logistics Costs

The gravity model is the workhorse of empirical international trade.[2] Typically, it is used to obtain econometric estimates of the sensitivity of trade flows with respect to particular trade cost factors, and to run counterfactual simulations based on those estimates. Novy (2010) turns the gravity model on its head to develop a methodology for inferring trade costs based on the observed pattern of trade and production. He starts from a variety of theory-based gravity models, and uses simple algebra to derive a theory-consistent expression for bilateral trade costs between two countries. His approach has been applied in a number of recent papers, such as: Jacks et al. (2008) on trade costs over the 1870-2000 period; Shepherd (2010), who uses the methodology to assess the effectiveness of trade facilitation programs in APEC and ASEAN; Brooks and Ferrarini (2010) on trade costs between India and China; Duval and Utoktham (2010) on trade costs in the Asia-Pacific; Miroudot et al. (2010) on trade costs in international services markets; and Olper and Raimondi (2009) on trade costs in food industries.

There are three main advantages to the Novy (2010) methodology. First, it is "top down", in the sense that it provides an all-inclusive measure of trade costs, covering all factors—even unobservables—affecting exports and imports. Second, its data requirements are limited to the value of domestic and international shipments, which can be approximated using commonly available data from national accounts and standard trade databases. It is not necessary to have policy data on the full range of trade costs in order to properly account for them using this approach. Third, the methodology is theory-based, and relies on an identity relationship rather than econometric estimation. There is thus no risk of omitted variable bias, or other problems that typically plague econometric estimates of gravity models. Of course, the cost of relying heavily on theory is that if it is incorrect, then the decomposition might

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[2] This section draws heavily on Shepherd (2011).

also be erroneous. However, Novy (2010) shows that the approach used here can be applied successfully to a variety of theoretical models of trade; it obviously captures a deep regularity in the relationship between trade costs, production, and trade flows. He also shows that it is highly robust to the possibility of measurement error.

In ad valorem equivalent terms, Novy's (2010) measure takes the following form:

(1) $\bar{t}_{ijt}^{k} = \left(\frac{t_{ijt}^{k} t_{jit}^{k}}{t_{iit}^{k} t_{jjt}^{k}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{iit}^{k} x_{jjt}^{k}}{x_{ijt}^{k} x_{jit}^{k}}\right)^{\frac{1}{2(s-1)}} - 1$

where: $\bar{t}_{ijt}^{k}$ is the geometric average of trade costs facing exports from country i to country j and those facing exports from country j to country i; k and t index sectors and time periods respectively; $\frac{t_{ijt}^{k}}{t_{iit}^{k}}$ is the cost of shipping goods from country i to country j relative to the cost of shipping them within country i; $\frac{x_{iit}^{k}}{x_{ijt}^{k}}$ is the value of goods shipped within country i relative to the value of those shipped from country i to country j; and s is a model parameter, usually the elasticity of substitution among product varieties within a sector.

The basic interpretation of equation (1) is straightforward: as the ratio of international trade relative to domestic shipments ($\frac{x_{ijt}^{k} x_{jit}^{k}}{x_{iit}^{k} x_{jjt}^{k}}$) increases, trade costs fall. In other words, trade costs must be lower when countries exhibit a greater tendency to trade with each other rather than with themselves. The precise relationship between trade costs and the ratio of trade to domestic shipments depends on how substitutable the goods in question are: in more homogeneous sectors, the effect on trade costs of a given change in the ratio is dampened.

However, it is important to be clear on a number of other aspects of the interpretation of $\bar{t}_{ijt}^{k}$. First, it represents average trade costs in both directions between i and j. The structure of the model is such

that it is not possible to derive expressions for unidirectional trade costs in terms of observables. From a policy perspective, it is therefore important to interpret changes in $\bar{t}_{ijt}^k$ cautiously: they might be caused by policy changes in country *i*, in country *j*, or in both simultaneously.

Second, as the first part of equation (1) indicates, $\bar{t}_{ijt}^k$ depends on the ratio of international trade costs to domestic trade costs ($\frac{t_{ijt}^k}{t_{iit}^k}$ and $\frac{t_{jit}^k}{t_{jjt}^k}$). One aspect of this connection is that some kinds of "behind-the-border" trade costs are effectively cancelled out in the final measure of average trade costs, namely those that affect domestic and foreign producers in exactly the same way. However, many behind-the-border measures discriminate in fact, if not in law, in the sense that it is more costly for foreign producers to obtain information on procedures, or navigate a path through domestic regulations and institutions. These kinds of differences are captured in $\bar{t}_{ijt}^k$. However, when comparing trade costs across countries, it is impossible to separately identify international versus domestic trade costs.

Third, $\bar{t}_{ijt}^k$ is an all-inclusive measure of trade costs, in the sense that it takes account of the full range of transaction costs affecting exports and imports. It thus takes account of logistics performance. It is not a measure of protection, like the World Bank's Trade Restrictiveness Indices. It takes account of tariff and non-tariff barriers to trade, but also includes a wide range of other trade cost factors typically captured in gravity models. Examples include geographical distance, and cultural or historical links. As a result, $\bar{t}_{ijt}^k$ is generally much larger in magnitude than the rates of protection trade economists are used to dealing with in measures such as the Overall Trade Restrictiveness Index (OTRI) or average applied tariffs.

Once the Novy (2010) trade cost measure has been calculated for a range of countries, it is possible to use an econometric decomposition to assess the impact of different factors on the overall level of trade costs. Shepherd (2011) adopts this approach to examine the impact of logistics performance on total trade costs in the Maghreb region (Table 5). Logistics costs are captured by a rescaled version of the LPI,

in which a higher score indicates poorer performance. Results show that logistics performance is clearly an important determinant of trade costs in this sample of countries: increasing logistics performance by 10% would tend to decrease trade costs by 6.5% in manufacturing and 8% in agriculture.

Table 5: Regression results using log(trade costs) as the dependent variable, 2007 only.

	(1) Manufacturing	(2) Agriculture	(3) Energy
Log(Logistics Costs)	**0.653*****	**0.808*****	**-0.061**
	(0.000)	**(0.000)**	**(0.668)**
Log(Tariff)	1.943	-2.786*	-115.840***
	(0.415)	(0.100)	(0.002)
Log(Distance)	0.397***	0.467***	0.372***
	(0.000)	(0.000)	(0.000)
No Common Border	0.207**	0.282**	0.225*
	(0.037)	(0.011)	(0.057)
No Common Language	0.190**	0.126	-0.038
	(0.011)	(0.228)	(0.704)
No Colonial Relationship	0.426***	0.050	0.192
	(0.001)	(0.652)	(0.278)
No Common Colonizer	0.055	-0.186	-0.344
	(0.564)	(0.312)	(0.191)
Constant	-3.961***	-3.476***	-1.582***
	(0.000)	(0.000)	(0.002)
R2	0.620	0.579	0.357
Observations	336	448	322

*Source: Shepherd (2011). Note: P-values based on robust standard errors corrected for clustering by country pair are included in parentheses below the parameter estimates. Statistical significance is indicated by * (10%), ** (5%), and *** (1%).*

To illustrate the relative importance of the various factors as determinants of overall trade costs, Chen and Novy (2010) suggest a variance decomposition approach. The percentage of the observed variance in trade costs accounted for by logistics, for example, is given by the following expression:

$$(3)\ Variance\ \% = \beta_1 \frac{cov\left[\log\left(\bar{t}_{ij}^k\right),\log\left(\overline{Logistics}_{ij}\right)\right]}{var\left[\log\left(\bar{t}_{ij}^k\right)\right]}$$

where β_1 is the relevant partial regression coefficient. Applying this approach to the model for manufacturing (Table 5, column 1) shows that logistics accounts for just over 15% of the observed variation in total trade costs. Tariffs, by comparison, account for only 0.6% of the variation in trade costs, but distance accounts for over one-third of the total. Although these are little more than "back of the envelope" calculations, it is clear that as far as policy-related impediments to trade are concerned, logistics is an issue of major quantitative importance. This result lines up well with the existing literature, which tends to suggest that the gains from reforming non-tariff measures—and in particular trade facilitation and logistics—outweigh the gains from comparable tariff reductions (Hoekman and Nicita, 2009).

Clearly, it will be important for future research to expand the country sample used for this analysis to include a broader range of countries. Inclusion of LPI scores for 2007 and 2009 will make it possible to control for a range of country-specific factors using fixed effects, thereby reducing the risk of omitted variables bias. Nonetheless, it seems likely that the basic results presented here will be confirmed, namely that logistics is a very important determinant of bilateral trade costs, accounting for perhaps as much as 15% of the total.

5 Identifying Logistics-Intensive Sectors

As noted above, an important question from a trade policy perspective relates to the impact of improved logistics performance on the pattern of sectoral specialization. At its most basic, trade theory suggests that as the price of logistics services falls relative to other goods and services in the economy, those sectors that use logistics particularly intensively will tend to undergo a relative expansion. We therefore expect improvements in logistics performance to affect relative sector size, and thus the pattern of specialization across countries.

To undertake a detailed analysis of the impacts of logistics performance on sectoral patterns of specialization, it would be necessary to incorporate the sector into a fully-specified general equilibrium model, such as the Global Trade Analysis Project (GTAP). GTAP currently includes a transport sector, which could be used as a first proxy for logistics. The model could therefore provide a platform for examining possible changes in the sectoral composition of production and trade by modeling improvements in logistics performance as reductions in transport costs. To do so, however, it would first be necessary to obtain an econometric estimate of the relationship between logistics performance and transport costs. Such work has not yet been undertaken, but future research focusing either on direct measures of transport costs or omnibus measures such as the Novy index discussed above could make an important contribution to a better understanding of this area.

Although the relationship between logistics and sectoral composition is a complex one, it is possible to use basic input-output data to provide some initial information on sectors in developing countries that are likely to be particularly sensitive to logistics performance. The OECD's STAN database input-output tables provide sectorally disaggregated data on intermediate input use, from which it is possible to construct measures of logistics intensity using the narrow and broad definitions discussed above; the medium definition cannot be used due to a lack of necessary sectoral detail in the input-output tables. "Logistics intensity" is defined simply as the percentage by value of total intermediate input use accounted for by logistics services.

Table 5 lists the five most logistics-intensive sectors in 11 non-OECD countries, using the latest available input-output data from OECD STAN. The first stylized fact that emerges is clearly that each country is different when it comes to logistics intensity in production: some sectors that are strongly logistics intensive in some countries (e.g., agriculture in South Africa) do not display that characteristic in most other countries. Second, it is nonetheless apparent that some sectors are logistics-intensive in a number

of economies, which suggests that modes of production are relatively similar across countries. Mining and minerals are examples. Third, a number of relatively "heavy" industries are logistics intensive in a range of countries. Boosting production and trade in such sectors relative to the rest of the economy would be consistent with the goal of export diversification in many developing countries. Recent cross-country empirical evidence indeed suggests that improved trade facilitation—of which logistics performance is an important component—can help boost export diversification (Dennis and Shepherd, 2011).

Table 6: Top five logistics-intensive manufacturing sectors based on input-output data; non-OECD countries.

Country	Year	Narrow Definition	Broad Definition
Argentina	1997	Wood products; Mining and quarrying; Minerals; Food products; Radio, television, and communications equipment.	Wood products; Office, accounting, and computing machinery; Metal products; Iron and steel; Minerals.
Brazil	2005	Mining and quarrying (energy and non-energy); Pharmaceuticals; Iron and steel; Minerals.	Mining and quarrying (energy and non-energy); Pharmaceuticals; Minerals; Textile products.
China	2005	Mining and quarrying (energy and non-energy); Minerals; Rubber and plastic products; Wood products.	Minerals; Rubber and plastic products; Mining and quarrying (energy and non-energy); Wood products.
India	2003/04	Medical, precision, and optical instruments; Minerals; Mining and quarrying; Textile products; Paper products.	Textile products; Iron and steel; Minerals; Medical, precision, and optical instruments; Food products.
Indonesia	2005	Wood products; Other manufacturing; Radio, television, and communication equipment; Pharmaceuticals; Medical, precision, and optical instruments.	Wood products; Other manufacturing; Radio, television, and communication equipment; Pharmaceuticals; Medical, precision, and optical instruments.
Romania	2005	Mining and quarrying; Coke and petroleum products; Minerals; Medical, precision, and optical instruments; Iron and steel.	Mining and quarrying; Food products; Motor vehicles; Medical, precision, and optical instruments; Minerals.
Russia	2000	Mining and quarrying; Minerals; Wood products; Iron and steel; Coke and petroleum products.	Coke and petroleum products; Minerals; Mining and quarrying; Iron and steel; Wood products.
South Africa	2005	Mining and quarrying; Agriculture; Rubber and plastic products; Coke and petroleum products.	Mining and quarrying; Agriculture; Textile products; Food products.
Taiwan	2006	Minerals; Wood products; Pulp and paper products; Other manufacturing; Machinery and equipment.	Wood products; Pulp and paper products; Agriculture; Minerals; Transport equipment.
Thailand	2005	Mining and quarrying (energy and non-energy); Minerals; Wood products; Pharmaceuticals.	Mining and quarrying; Wood products; Pharmaceuticals; Agriculture; Pulp and paper products.
Vietnam	2000	Wood products; Coke and petroleum products; Mining and quarrying (energy and non-energy); Building and repairing of ships and boats.	Pulp and paper products; Textile products; Motor vehicles; Electrical machinery; Medical, precision, and optical instruments.

Source: OECD STAN database, input-output tables. Logistics intensity is defined as the percentage of total intermediate input use accounted for by logistics (narrow and broad definitions).

6 Conclusion

This paper has explored a number of different data sources and methodologies in an effort to move forward on the analysis of logistics costs from a trade policy research perspective. In the future, it will be important to distinguish between data collection efforts that are industry-driven—such as estimates of total logistics costs in GDP—and those that are research-driven. The former are useful in establishing the size of the sector and in attracting attention from researchers and policy analysts. However, the results presented here suggest that they may be of limited use from a trade research point of view. The reason is that measures of sector size exhibit little systematic relationship with economic outputs and inputs in a cross-country regression framework. Moreover, the relationship between sector size and performance appears to be non-monotonic, which makes it difficult to draw meaningful policy conclusions based on size alone. By contrast, performance measures such as prices generally display a more significant relationship with important economic variables.

The work presented here has three important implications for future research and data collection work in this area. First, the data and analysis presented here has relied on descriptive statistical techniques only. There is clearly major scope to exploit data sources such as national accounts, input-output tables, and firm-level data within the framework of a fully-specific regression problem. Such an approach could properly account for intervening causes, and establish more robust results than those presented here. In tandem with future data collection efforts, it will be important to make better use of existing data sources too.

Second, it is important that future data collection efforts emphasize performance measures rather than size measures. Data on logistics expenditures is important in either case, but the choice of denominator is crucial in terms of making the resulting data most useful for applied trade policy researchers. Ideally, logistics costs should be converted into an ad valorem equivalent—i.e., a percent of the landed price of

traded goods—which is the measure trade economists most commonly work with in their models. Alternatively, "pure" performance measures like the LPI can also be used to estimate ad valorem equivalents by applying the Novy (2010) methodology.

Third, measures of logistics intensity should also be part of the data and analysis framework moving forward. Some existing work has already focused on logistics costs as a percentage of total costs, which is essentially a measure of intensity. Moving further in this direction will help fuel research that identifies sectors in particular countries that are most sensitive to improvements in logistics performance, and which therefore will tend to expand relative to other sectors in the face of logistics sector reforms. From a policy and political economy point of view, it will be important to identify such sectors and make them aware of the potential role logistics can play in facilitating their growth.

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