Routes, Exports, and Employment in Developing Countries: Following the Trace of the Inca Roads[♦]

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Abstract

Domestic road infrastructure programs are often justified on the basis of their presumed positive effects on exports and accordingly on employment. However, available evidence on to what extent these effects actually materialize is very limited. In this paper, we fill this gap in the literature. In so doing, we take advantage of detailed geo-referenced data on firm-level trade and historical and current road infrastructure on Peru and specifically use the distance to and the distance that could have been traveled along roads belonging to the Inca road network as instruments to address potential endogeneity of transportation infrastructure to trade. We find that improvements in this infrastructure have had a significant positive impact on firms' exports and thereby on job growth.

Keyword: Infrastructure, Exports, Employment, Peru
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1 Introduction

In policy circles domestic transport infrastructure is seen as a key determinant of exports. Exports, in turn, are assumed to lead to job creation. More precisely, among policymakers, there is a well rooted idea according to which improved infrastructure can generate employment growth through facilitating increased exports. Statements in official documents introducing public export development programs of several countries around the world are illustrative in this regard. The report presenting the United States National Export Initiative 2011 is a clear example. According to this report, "*American businesses cannot participate in the global economy if they cannot get their products out the door…Deficiencies throughout America's transportation system…severely impact the ability of businesses to transport their goods to global markets…Now more than ever, America's ability to support additional jobs here at home depends on the ability to export goods and services to the world…*" Of course, this argumentative line is not exclusive of developed countries. For instance, in Peru, the country we focus on in this paper, the *Plan Estratégico Nacional Exportador* (Strategic National Export Plan) 2003-2013 states "*The exporting sector…is one of the most affected by the infrastructure deficit, generally in transportation, which generates competitiveness losses relative to competing countries…In a context of increasing economic globalization, the exporting sector plays a fundamental role as a growth engine, in generating employment, and in fostering the development of nations…*".

Simple correlations seem to indicate that such a link may exist between transport infrastructure, exports, and employment.[1] This is illustrated in Figure 1, which shows a positive relationship between expansion in the road network and export growth as well as between export growth and employment growth across countries over the period 2003-2010. Interestingly, Peru appears among those countries with the largest increase in the length of this network in most recent years. Anecdotal evidence from the country itself also points to in the same direction. Thus, exports from municipalities whose road connections to their main ports improved grew on average more than 150% over the period 2003-2010. Employment did it by 30%. Firm-specific experiences are a testimony to this fact. Take for example the case of the company *Agroindustrial Santa Lucía S.A.* This company created in 1994 is located in Tocache (Department of San Martín) and primarily produces and exports palm hearts to France through the port in Callao (see Figure 2). As a result of the new roads built over the last decade, the distance to this port declined. Interestingly, this firm's exports and employment increased by 479% and 93.3% between 2003 and 2010, respectively. Another example in the same department is the *Cooperativa Agraria Cacaotera ACOPAGRO*, a cocoa producer located in Juanjuí, whose exports and number of employees grew 259.5%

[1] According to a recent survey of the United Kingdom Manufacturers association, two-thirds of export-intensive manufacturers identify investment in road access to international gateways as critical to their growth.

and 119.1% over the same period, respectively. These correlations and anecdotal evidence are often used by practitioners to justify investment in infrastructure.

Yet, although suggestive, this kind of evidence is not informative of causality. The reason is that there are potential endogeneity problems affecting both the relationship between internal infrastructure and exporting as well as that between exporting and employment. Thus, road improvements might be thought to favor better export performance of regions receiving infrastructure investments, but is also equally possible that increasing exports results in investments in these regions to reduce transport costs.[2] Similarly, firms may hire more workers in response to additional demand from abroad or they may increase their number of employees to reach a scale that will make them later easier to deepen their penetration into foreign markets. Unfortunately, available evidence on to what extent infrastructure matters for exports is virtually inexistent. In the same vein, whether these exports make a difference in terms of employment is far from clear. In this paper, we aim at filing this gap in the literature by using a rich dataset and implementing a convincing identification strategy.

More precisely, our paper addresses one main question: What are the effects of domestic road infrastructure on exports? As a byproduct, although admittedly in a more indicative manner, we also shed new light on a second related question: If anything, how do additional exports affect employment creation? In answering these questions, we exploit highly disaggregated firm-level export data that inform the exact geographical origin of the exports and the location of the ports through which the exports exit the country in 2003 and 2010 along with detailed geo-referenced information on recent and historical domestic road infrastructure for Peru.

Between 2003 and 2010, more than 5,000 kilometers of new routes were constructed in Peru, which roughly amounted to a more than 10% net expansion in the country's main (national and departmental) road network (see Figure 3) (see Cornejo Ramirez, 2010; and MTC, 2012).[3] This expansion was made it possible through a 610% (nominal, in US dollars terms) increase in the public resources allocated to road infrastructure to account for 1.3% of the country's GDP in 2010 up from 0.5% in 2003 (see MEF, 2013).[4]

New roads were asymmetrically distributed across regions. As a consequence, depending on the route(s) from the plants to the ports, airports or borders used in exiting the country, available transport infrastructure increased and distance traveled and internal transport costs incurred diminished for some origins while those for others remained the same. Hence, by contrasting exports in both groups while controlling for potential confounding factors, we can in principle estimate the impact of this new

[2] From a political economy point of view, this would be more likely the case when exporting firms are relatively large as it could be in our case (see Section 2) and would therefore tend to have more bargaining power.

[3] In addition to national and departmental roads, there are local roads. These roads are mostly non-paved and are generally in bad shape (see MTC, 2005). As a consequence, they are not commonly used for international trade shipments. For further information see Volpe Martincus et al. (2013a).

[4] The average annual budget for investments executed by the Peruvian Ministry of Transport and Communications (MTC) more than doubled between 2000-2002 and 2003-2010. In particular, average annual budgetary execution increased by more than 170% from 2000-2002 to 2006-2010.

infrastructure on firms' exports. More specifically, we can compare the before and after change in exports from economic entities whose original distance to the exit point-as determined by a methodology that combines distance data and Geographic Information System (GIS) analysis- were later reduced due to the construction of new roads with those whose distances did not experience any change. Figure 4 provides a visualization of the most basic version of this differences-in-differences strategy at the municipal level. This figure specifically shows the non-conditional change in total exports for municipalities whose routes to the relevant ports became shorter thanks to the new roads and that for their peers with no changes in distances to their reference ports for two periods 1999-2002 and 2003-2010. As requested by this strategy, both groups' exports followed parallel trends before transport infrastructure innovations (1999-2002) and, interestingly, their trajectories began to diverge in most recent years when these innovations occurred (2003-2010).[5] Figure 5 uses four concrete cases to illustrate this result: two manufacturers of food products (*Cartavio S.A.A.* and *Danper Trujillo S.A.C.*) located in the department of La Libertad and two manufacturers of textile products (*Inversiones Comindustria S.A.* and *Industrial Hilandera S.A.C.*) located in the department of Lima. Figures below the map clearly indicate that, whereas firms in each group exhibited similar export growth before the expansion of the road infrastructure, those firms whose shipping distances declined as a consequence of such expansion registered significantly larger increases in their foreign sales afterwards.

These simple but certainly suggestive difference-in-differences estimations do not suffice, however, to identify the effects of interest. As mentioned above, infrastructure improvements can be endogenous to exporting. We therefore apply an instrumental variables approach whereby the Inca road network is used as an exogenous source of variation in transport infrastructure. As we shall explain below, this network was clearly built up for reasons entirely disconnected with current foreign trade, but it is a good predictor of current road infrastructure and, including an appropriate set of control variables, it can be safely considered to affect today's exports only through their correlation with the spatial allocation of new roads. In particular, we instrument the change in road infrastructure between 2003 and 2010 with both *the distance from* the geographical origin of the exports to the nearest road that was part of the Inca network and *the distance between* this origin and current port that could have been traveled along roads in this network. We thereby accomplish our first and primary task, namely, to obtain a consistent estimate of the effects of domestic transport infrastructure on exports. In order to achieve our secondary goal and thus assess whether and how exports associated with infrastructure improvements influence employment, we then use the predicted values from the so estimated export equation as a an instrument for the actual change in exports in an equation in which changes in employment are explained by changes in exports

[5] The t-test of differences in means indicate that average export growth of these two groups of municipalities are not significantly different from each other over the period 1999-2002 but became so over the period 2003-2010. A table with the test statistics is available from the authors upon request.

after conditioning by relevant covariates. We find that domestic road infrastructure has had a strong positive impact on firms' exports and that this impact actually translated into employment generation.

Our analysis contributes to and combines at least two different literatures. First, this analysis adds to a series of recent papers that seriously account for potential endogeneity when assessing the effects of domestic infrastructure on economic outcomes.[6] Thus, Fernald (1999) estimates the impact of roads on productivity growth across industries with different vehicle intensity in the United States based on a non-linear regression equation that combines aggregate and sectorally disaggregated data to get rid of an omitted variable-driven-endogeneity problem. Moreover, Baum-Snow (2007) and Michaels (2008) use, among others, plans for the United States' Interstate Highway System –that were designed to strengthen national defense and improve connectivity among major metropolitan areas and with Canada and Mexico- as instruments for the actual highways to examine their effects on suburbanization and relative demand for skilled workers, respectively. Duranton and Turner (2012) consider a similar instrument and two additional ones derived from historical data on the railroad network and the exploration routes between 1528 and 1850 to analyze the effects of interstate highways on the growth of major United States' cities. In a follow up study, Duranton et al. (2013) utilize these instruments to identify the effects of highways between and within cities on the weight and value of bilateral trade between United States' large cities.[7] Gibbons et al. (2012) investigate the impact of road improvements on firm employment and productivity in Great Britain over the period 1998-2007. In their paper, endogeneity of road construction scheme placements is dealt with by taking into account that such transport schemes were improvements to the major highway system primarily aimed at increasing long-distance network performance and thus not specifically targeted to local economies development and hence by using only areas that were close to the road improvements.

Noteworthy, existing analyses are not confined to developed countries, but also refer to developing counterparts. For instance, Datta (2012) examines the impact of India's Golden Quadrilateral Program -a major project aimed at improving the quality of existing highways connecting the four largest cities in India- on firms' inventories and sourcing patterns. In carrying out this examination, he uses a difference-in-differences approach, whereby status on and off of the improved highways and distance from them are used as treatment variables. Gahni et al. (2012) study the effects of the same infrastructure initiative on the organization and performance (i.e., employment and productivity) of the Indian formal

[6] There is also an incipient literature that looks at the impact of infrastructure across countries on economic outcomes. Thus, Feyer (2009), Akerman (2009), and Volpe Martincus et al. (2013b) take the closing of the Suez Canal, the construction of the bridge on the Öresund Straight, and the environmentally-related blockade of the main bridge connecting Argentina and Uruguay, as natural experiments to investigate how international transport costs affect trade, respectively. More generally, there is a large number of studies showing that international transport costs have a significant negative impact on trade (see, e.g., Hummels, 2001; Limão, and Venables, 2001; Clark et al., 2004; Blonigen and Wilson, 2008; Mesquita Moreira et al., 2008).

[7] Using the US Commodity Flow Survey, Hillberry and Hummels (2008) investigate how the intra-national trade components co-vary with spatial frictions. They find that the number of shipments and the number of unique establishments-destinations decrease pronouncedly with distance.

manufacturing sector. They also apply a difference-in-differences estimation strategy, through which they compare districts were located at different distances from the highway network among those that were not the hubs whose connectivity the project intended to improve. Donalson (2013) also concentrates on India, but instead of considering road infrastructure, he explores the impact of the construction of India's railroad network on price gaps, interregional and international trade, and real income levels. In this case, identification is based on the prevalence of military reasons as a driving force for the placement of most involved projects and the impossibility of targeting specific locations due to the networked nature of railroad technology. Railways are also the focus of Jedwab and Moradi (2013), who investigate the impact of the construction of two lines linking the coast and the mining areas and the hinterland during the British colonial era on Ghana's commercial agriculture (cocoa production) and urban growth. Banerjee et al. (2012) look at the Chinese experience. They assess the influence of access to transport networks on this country's regional economic outcomes by taking advantage of the fact that these networks tend to connect historical cities.[8] Finally, Volpe Martincus and Blyde (2013) estimate the –primary short run- effects of domestic transport infrastructure on firms' exports exploiting the random and exogenous variation in this infrastructure associated with the earthquake that took place in Chile in February of 2010.[9] Overall, this body of research conveys a consistent message: infrastructure seems to have been an important driving force for the variables considered in these studies. Here, we also explore how road infrastructure affects export using comprehensive and detailed firm-level data, but we implement an entirely different identification strategy that relies on unique historical data. Importantly, we look farther than a short run response by considering a longer time period and, to the extent allowed by the data, go beyond the impact on exports by tracing its subsequent implications for other economic outcomes.

Second, in this latter sense, our study also contributes to a number of papers that examine the effects of exporting on firm performance while properly correcting for endogeneity. Within this extensive literature (e.g., Clerides et al., 1998; Bernard and Jensen, 1999; Girma et al., 2003; van Biesebroeck, 2005; De Loecker, 2007), our paper is methodologically closer to two recent contributions by Lileeva and Trefler (2010) and especially Park et al. (2010). Lileeva and Trefler (2010) investigate how exporting affected Canadian plants' labor productivity and innovation by using a measure of the tariff cuts faced in the United States by each specific plant as an instrument for exporting. They find that Canadian plants that were induced by these tariff cuts to start exporting or to export more increased their labor productivity, engaged in more product innovation, and had higher rates of technology adoption. Similarly, Park et al. (2010) analyze the impact of exporting on Chinese firms' performance as captured by variables such as productivity, employment, sales, sales per worker, return on assets, capital, and capital per worker over

[8] Rothenberg (2012) investigates how improvements in road quality have affected the location of firms in Indonesia.

[9] See references therein on preexisting analyses of the effects of transport infrastructure on trade. Most of these studies leave the endogeneity problems unaddressed.

the period 1995-2000. In their analysis, exporting is instrumented with firm-specific exchange rate shocks based on the destination of firms' exports before the Asian crisis. Their results indicate exports primarily increased firm productivity, total sales, and returns on assets.[10] Unlike these papers, we examine –to our knowledge for the first time- the employment effects associated with increased exports driven by transport infrastructure improvements.

The remainder of this paper is organized as follows. Section 2 introduces the dataset and presents basic statistics and preliminary evidence. Section 3 describes the Inca road network and makes the case of using variables related to this transport infrastructure as a valid identification strategy. Section 4 discusses the impact of road infrastructure on exports. Section 5 examines the effect of exports on employment, and Section 6 concludes.

2 Dataset and Descriptive Evidence

Our dataset consists of three main databases. First, we have highly disaggregated export data for 2003 and 2010 from the Peruvian customs. Data are reported at the transaction level and cover the entire universe of transactions in these years. Specifically, each record includes the firm's tax ID, the geographical origin of the flow (*municipalidad*), the product code (6-digit HS), the port, airport or land border (hereafter ports) through which the good exits Peru, the destination country, the export value in US dollars, and the quantity (weight) in kilograms.[11] Hence, for each firm, we know the geographical origin of their exports, the export value, the quantity shipped, the number of shipments, and the exiting port for each of its product-destinations. We should mention herein that the sum of these firms' exports virtually adds up to the total merchandise exports as reported by the Central Bank of Peru, with the annual difference being always less than 1%. Second, we have data on employment, sector of activity, and starting date from Peru's National Tax Agency, SUNAT. Firms are also identified by their tax ID in this case, so that the two datasets could be easily merged.

The upper panel of Table 1 presents a snapshot of Peruvian total exports in 2003 and 2010 –which will be the baseline initial and final sample years in our econometric analysis- along with key export extensive margin indicators. Exports grew almost 300% between these years to reach 35.7 billion US dollars in 2010. These foreign sales expanded along the firm, destination, and product extensive margins. Thus, the number of firms, destination countries, and exported products increased by 47.7%, 7.1%, and 15.7% from 2003 to 2010, respectively. Yet, most of the expansion is accounted for by a larger intensive margin on the

[10] Brambilla et al. (2012) use the exogenous changes in exports and export destinations associated with the 1999 Brazilian devaluation to identify the causal effect of exporting and of exporting to high-income countries on skill utilization by Argentinean manufacturing firms.

[11] Peru is administratively organized in 25 departments. These departments are, in turn, subdivided in provinces (195 in total) comprising several districts (1,841 in total). Lima is the capital city of the country and is located on the coast.

product-country dimension, i.e., larger average exports by product and country. This was the results of both larger average shipments and a larger number of shipments, which raised nearly 150%. These shipments exit the country through 18 ports. Roughly 1,600 firms experienced a reduction in the distance to these ports as a consequence of the new roads constructed over the period.

The lower panel of Table 1 characterizes the average Peruvian exporter in these years. On average, in 2010 exporting firms had 109 employees and sold 8.1 products to 2.7 countries for approximately 4.8 million US dollars. In selling abroad, each of these firms made 98 annual shipments through one primary port.

In addition, the Peruvian Ministry of Transport and Communications (MTC) kindly provided us with geo-referenced versions of the maps of the Peruvian road (national and departmental) networks in 2003 and 2010 (see Figure 6). Assuming that profit-maximizing firms have incentives to select the least-distance route between any two observed shipping locations, both the domestic route(s) that each firm originally used from the production facilities to the exiting ports in shipping each of their products to each of their destination countries and the routes utilized after the new roads were built can be identified applying a method that makes use of spatially geo-referenced data on the road network (see, e.g., Combes and Lafourcade, 2005).[12]

The average exporter was located 237.2 kilometers away from its main port in 2003 (see Table 1). As mentioned above, new roads were asymmetrically distributed over space. Figure 7 shows the distribution of the share of each Peruvian department in the total number of exporters whose road connection with their main port improved as consequence of these roads and that of their share in the total number of peers not experiencing any change in this regard across Peruvian departments. These distributions clearly resemble each other. In fact, according to the Kolmogorov-Smirnov test, these distributions are not significantly different.[13] With these road infrastructure improvements in place, the average distance to this main ports declined 11.9% from 2003 to 2010. Note that this is an average across all exporters, i.e., taking into account both those with changed and unchanged shipping distances. If we instead consider only those firms that could actually use shorter-distance routes thanks to the new roads, this reduction doubles to reach 23.1%. Instead of a single moment, Figure 8 shows the entire distribution of distances traveled between production plants and exit nodes at the beginning and the end of the sample period. This figure reveals that the innovations to the road infrastructure caused an important shift in the distribution of distances and predictably a reduction in domestic transport costs. In figure 9, we compare

[12] More precisely, we apply a method based on a Geographic Information System (GIS). This system consists of a digitalized real transport network that connects the country's municipalities with each other, including those where ports are located. The network is composed of several arcs that correspond to the different types of roads belonging to the road system (i.e., highways, primary roads, and secondary roads). The Arc View program is used to identify the least-distance itinerary between each municipality of origin and each exit port, whereby this distance is calculated by adding up the different arcs that connect the respective intermediate end-nodes (see Volpe Martincus and Blyde, 2013).

[13] The test statistics are available from the authors upon request.

non-parametrically the unconditional growth of exports whose distances to the respective main port decreased with that of their counterparts whose distances remained the same. This figure suggests that the former experienced larger expansions than the latter. More specifically, according to the procedure proposed by Delgado et al. (2002), the distribution of the growth rates of exports with declining distances stochastically dominates that of the exports with invariant distances.[14]

As discussed above, such simple comparisons are most likely not able to properly identify the effect of road infrastructure on exports, so we resort to instrumental variables estimation. In this sense, we have obtained digital images of maps of the different portions of the Inca road networks (see Regal, 1936) and have converted these images into a digital map with the same format and projection as the maps of the 2003 and 2010 road networks (see Figure 10). Based on this map, we construct the two variables that will be used as instruments in our estimations: the distance from each municipal capital to the Inca road network and the distance that could have been traveled on this network between any given two locations in Peru.

3 The Inca Roads

The Inca road system, a network of approximately 40,000 kilometers of routes on some of the roughest terrains on earth, is probably one of the most impressive infrastructures ever created in history. Its origins can be primarily traced back to the mid-fifteen century when the small Inca Kingdom in the Andean Area of South America became the Inca Empire (the *Tawantinsuyu*) after gaining hegemony over its neighbors and expanding to other territories.

This road network extended from Quito, Ecuador, to Chile and Northern Argentina, thus connecting Peru from North to South.[15] Cuzco, the capital of the Inca Empire, was the core of the road system, which consisted of four main routes that departed from important worship centers, the *Huacay-Pata* and *Cusi-Pata* squares: *Chinchaysuyu* (to the North), *Cuntisuyu* (to the West), *Collasuyu* (to the South), and *Antisuyu* (to the East) (see Regal, 1936) (see Figure 10). Each of these roads drove to one of the regions in which the Inca Administration divided the Empire. In all historical accounts, the *Chinchasuyu* or Quito-Cuzco highland route was the most important.

Straight lines were the predominant and most relevant feature of the Inca roads' design, particularly in flat territories (see Regal, 1936; and Romero, 1949). General long-distance straightness was not interrupted with significant detours to include additional population centers. More specifically, roads

[14] The associated tests statistics are available from the authors upon request.
[15] Peru is the third roughest country in the world, only surpassed by China and Nepal (see Ramcharan, 2009).

rarely deflected from a straight course by more than 20 degrees within five kilometers. In the Andean highlands the roads were constructed to avoid major curves or changes in direction (see Hyslop, 1984).[16]

Still, geographical factors shaped the network (see Hyslop, 1984). Thus, for natural reasons, roads tended to stay below 5,000 meters of altitude. In addition, steep slopes appeared to be bypassed, especially those which were dangerously high for road developers. Whenever possible, the paths passed through flat intermountain valleys or over plateau regions. Furthermore, the roads skirted large tracts of sterile deserts, rather than make a direct passage over them.[17] For instance, the North-South road on the Pacific coast did not always follow the sea coast, but often ran inland along the Andean foothills, where more sources of water were available. While steering towards scarce water in dry areas, roads also dodge abundant water in the form of rivers or marshy terrains. Thus, in the rainy Andean highlands, the Incas appeared to have placed the roads on the upper reaches of the slopes, while in arid regions such as the Argentine foothills, the paths ran on the lower reaches of a valley's slope, often near to its river.

Historical, political, and cultural factors also accounted for the spatial pattern of the road network (see Hyslop, 1984). Thus, some roads followed regional paths of primitive, pre-Inca populations (see Squier, 1877). In fact, the Incas likely inherited and improved part of their road network, as the system was too extensive and complicated to have been built over the short lifespan of the Inca Empire, even with modern technology (see Lumbreras, 1974). Specifically, archaeological studies have confirmed that the Lambayeque-Moche, Cajamarca-Huamachuco, and Cañete sections are pre-Inca constructions. The network also served religious, military, and administrative and communication purposes. For example, the roads to the Inca's high altitude sanctuaries clearly had religious objectives (see Schobinger, 1963). In general, roads were used to mobilize troops and thereby ensure military dominance of the different regions. In particular, some of the paths led to the Empire's borders, where these troops marched and were stationed to protect it (see Arciniegas, 1990; and Morris, 1972). The road network was also designed to make possible the communication between urban settlements (see Regal, 1936).

In this paper, we primarily aim at identifying the effect of road infrastructure on exports and thereby on employment. The obvious challenge we face is that infrastructure can be endogenous to exports either because new roads may have been constructed based on expected future trade or because of missing variables that may drive both spatial allocation of new routes and exports. In the analysis below we instrument the change in available road infrastructure (i.e., new road construction leading to reduced distance traveled) with two variables that measure the accessibility to and the coverage of the available Inca road network, namely, the distance to the nearest route that was part of this network and the

[16] The roads were also punctuated with notorious regularity by the *tampus* or night lodgings.

[17] A variety of Inca roads crossed great distances of sandy surface. Some of these roads were informal footpaths, while others had margins marked by stones, sidewalls, or surfaces cleared of stones. Roads crossing agricultural terrains had sidewalls mainly to protect crops from passing travelers and animals.

distance that could have been traveled along these roads between each origin and each city where current ports are located, respectively.[18]

These two variables are valid as instruments as long as they predict recent road infrastructure improvements, but are otherwise uncorrelated with exports. This involves two conditions. First, these variables must be partially correlated with infrastructure innovations once the other relevant variables have been netted out. As suggested by Figure 11, our both instruments are very likely to predict the modern road network as well as its evolution over time. The direction of the relationship, however, can *a priori* go in either way. On one hand, similar to the United States exploration routes, the Inca roads resulted from a search for an easy way to get from one place to another place on foot or animal-back. Since a good route for a man or an animal can be assumed to be also good for a car, the Inca roads will often be good routes for contemporary highways (see Duranton et al., 2013). In such a case, we would expect a negative correlation between infrastructure improvements and distance to the Inca road network and a positive correlation between infrastructure improvements and the distance that could have been traveled on this network between two locations. On the other hand, it may also be perfectly possible that, while first, older roads were already constructed following the trace of and thus overlapped with the Inca road network, newer, more recent roads may be built in regions that are less-infrastructure developed and farther away from where the Inca road network was. Here, a positive correlation between infrastructure improvements and distance to the Inca roads would prevail.

Second, the variables chosen as instruments must be uncorrelated with the error term, i.e., they must be exogenous, which requires to properly accounting for factors that influence exports and are correlated with both the access to and the extension of available Inca roads. In this sense, the construction of the roads had no association with past overseas trade, which was virtually inexistent. Several researchers coincide in that the closed and family character of the Incas' economic organization did not even create room for markets and domestic trade.[19] In particular, within this organization each family produced what was needed for subsistence and, if any, domestic trade was extremely restricted to specific products (see Romero, 1949; D'Altroy, 1992; and Murra, 2002).[20] This system sharply contrasts with that prevailing in other Latin American Pre-Columbian Civilizations such as the Aztecas where domestic trade played a much more preponderant role. Among other things, this scheme was possible due to the notorious local ecological diversity of the area that currently corresponds to Peru, which allowed inhabitants of specific

[18] For firms off the Inca road network, distances on this network are computed from the point that would have been closest to the municipalities where their export flows are shipped from.

[19] There was no currency in the Inca Empire (see Rodriguez, 1977; and Arciniegas, 1990). One of the most often cited and highly valued sources of information about the Inca civilization are the memoirs of Polo de Ondegardo, a Spanish Kingdom representative, who arrived to the Andean region in 1540 and was in charge of supervising Incas' activities. In his records there is no single mention to the existence of markets or merchants (Romero, 1949).

[20] According to Murra (2002), the Incas implemented a system whereby each family group simultaneously had parcels located in different areas, which allowed them to have access to diverse crops. Kinship as well as military and religious ties guaranteed production sharing.

regions to have access to a broad variety of natural products without the need to resort to cross-regional exchanges (see Arciniegas, 1990; and Contreras, 2010).

The most relevant reference to internal trade corresponds to the exchange of a shell called the *mullu*, which was considered a holy object able to attract the rain (see Rostworowski, 1970). The *mullu* was collected in the South coast of Peru and the artisans who sculpted the mollusks periodically traveled to Cuzco, although they never actually "sold" them (see, e.g., Murra, 2002).[21]

Further, the Inca road network can hardly be considered to have been designed to facilitate today's exports. The mere length of time and the fundamental political, economic, and social changes occurred since the Inca era speaks in favor of using it for instrumentation purposes. The shifts in economic geography are a testimony to that fact. Thus, while Cuzco was the core of the Inca Empire, with the establishment of the Spanish colony the political and economic center moved to Lima, Peru's current capital city (see Figure 10). This created an entirely new spatial and transport dynamics as goods started to be shipped from Lima (goods coming from Spain consumed by local authorities and settlers) and to Lima (goods going to Spain, primarily precious metals) (see Contreras, 2010).

Admittedly, based on the previous historical accounting, it might be argued that cities that were large and productive in the Inca times and got a better access to the road network are still today large and productive and accordingly tend to export more or that there are geographical factors that may be correlated with both the Inca road network and production and exports (see, e.g., Ramcharan, 2009).[22] This could potentially lead to a violation of the exclusion restriction. Notice, however, that, as we shall explain and show below, our main export equation includes a rich set of fixed effects that help circumvent the problem of missing variables and can be safely assumed to preclude a correlation between the instruments and exports unrelated to new road construction.

4 Domestic Road Infrastructure and Exports

We aim at estimating the effects of domestic road infrastructure on exports. Clearly, there are factors other than this infrastructure that may affect firms' foreign sales. Thus, these sales may be larger because higher firm productivity or other public policies. Failure to properly account for these other factors would result in biased impact estimates. Our baseline empirical model of exports accordingly includes appropriate sets of fixed effects to control for such factors. We specifically postulate the following export equation:

[21] While Hartmann (1968) argues that some domestic trade took place in the North of the Empire, later revisions by Oberem (1978) and Salomon (1986) challenge this view and unambiguously conclude that, if present at all, trade was very limited and developed at a very late stage. The thesis that postulates the existence of markets and trade was also questioned by Noejovich (2003).

[22] Roughness imposes severe challenges to development and maintenance of transport networks. In fact, according to recent estimates, a one percent increase in roughness is associated with about one percent decline in the number of kilometers of roadway (see Ramcharan, 2009).

$$lnX_{frspct} = \alpha D_{frspct} + \lambda_{frspc} + \theta_{rst} + \varepsilon_{frspct} \qquad (1)$$

where f denotes firm, r stands for region (Department), s indicates sector (2-digit ISIC), p corresponds to product, c refers to country, and t indexes year (i.e., transactional data are aggregated at an annual frequency). The main variables are X and D. The former represents export value. The latter is a binary indicator that takes the value of one if firm f located in region r and belonging to sector s uses a shorter distance route to ship product p to the main port through which it exports to country c and 0 if it uses a same-distance route.[23] The coefficient on the indicator variable D, α, is accordingly our parameter of interest. If $\alpha > 0$ ($\alpha = 0$), then reduced distance –and hence transport costs- due to new roads has had a positive (no) impact on exports. The remaining terms of Equation (1) correspond to control variables. Thus, λ_{frspc} is a set of firm-region-sector-product-country fixed effects that captures, for instance, the firm's knowledge of the market for a given product in a given country; θ_{rst} is a set of region-sector-year fixed effects that absorb the influence of sector-region shocks such as, for example, changes in other public policies aimed at promoting exports in specific regions or sectors (see, e.g., Volpe Martincus, 2010) as well as changes in foreign demand for goods produced by firms in particular sectors that are primarily concentrated in particular regions; and ε is the error term.

In estimating Equation (1), we use differencing to eliminate the firm-product-country fixed effects.[24] Further, we aggregate time series information into two periods 2003 and 2010. In so doing, we address the serial correlation problem to which equations such as ours are typically subject (see Bertrand et al., 2004). We therefore estimate the following baseline equation:

$$\Delta lnX_{frspc1} = \alpha D_{frspc1} + \theta'_{rs} + \varepsilon'_{frspc} \qquad (2)$$

where we already have taken into account that $\Delta D_{frspc1} = D_{frspc1}$ because no infrastructure improvements took place in the initial period (i.e., $D_{frspc0} = 0 \; \forall frspc$); $\theta'_{rs} = \theta_{rs1} - \theta_{rs0}$ accounts for all region-sector shocks; and $\varepsilon'_{frspc} = \varepsilon_{frspc1} - \varepsilon_{frspc0}$.

Notice that Equation (2) essentially corresponds to a difference-in-difference estimation, whereby the before and after change in exports whose routes' length did not change is used as an estimate of the counterfactual for those exports whose routes' length declined as a result of the increased availability of road infrastructure. By comparing these changes, the difference-in-differences estimator permits controlling for observed and unobserved time-invariant factors as well as time-varying ones common to both treated and comparison groups that might be correlated with being exposed to the positive infrastructure shock and exports (see, e.g., Galiani et al., 2008). Equation (2) additionally includes

[23] We use a binary indicator to impose less parametric structure. In particular, distance to the main port is considered because most firms just use one port in shipping a given product to a given destination. In fact, the average (median) number of ports per firm-product-country is 1.02 (1). Hence, unsurprisingly, estimation results are virtually identical when using instead the median distance or the weighted average of the distances in constructing the main explanatory variable. These alternative estimation results are not presented here but are available from the authors upon request.

[24] When the number of periods is equal to two, first-differencing and fixed effect estimation produce identical estimates and inference (see Wooldridge, 2002).

covariates that account for systematic differences across region-sectors pairs, thus substantially reducing the risk of omitted variable biases and particularly of heterogeneity in export dynamics along these dimensions.

Yet, as discussed above, our main explanatory variable, D, can be endogenous to exports. Hence, as mentioned above, we apply an instrumental variables approach to properly identify its effect. In particular, in order to isolate a source of variation in road infrastructure that is exogenous with respect to firm exports, we use as instruments two variables related to the Inca road network: the distance from the geographical origin of the export flow to the nearest Inca road and the distance that could have been traveled along the Inca road network from that origin to the respective point through which this flow leaves the country.[25] As stated earlier, these two variables are likely to be correlated with current expansions in the road network and are unlikely to affect today's exports directly.[26] More formally, we estimate the following first-stage equation:

$$D_{frspc1} = \delta lnDistance\ to\ Inca\ Roads_{frspc} + \rho lnDistance\ on\ Inca\ Roads_{frspc} + \gamma_{rs} + \epsilon_{frspc} \qquad (3)$$

Table 2 presents both ordinary least squares and instrumental variables estimates of Equation (2), the estimates of Equation (3), and the standard specification tests. The test statistics clearly confirm the validity of our instruments. More specifically, the F test statistic is well above 10 (see Staiger and Stock, 1997) and 11.52 (see Stock and Yogo, 2005), thus suggesting that the two Inca road network-related variables are indeed correlated with recent innovations in transportation infrastructure.[27] Consistently, according to the Kleibergen-Paap test statistic, our estimation does not seem to suffer from a weak instruments problem. In addition, the Hansen test for over-identifying restrictions formally indicates that, after conditioning by region-sector fixed effects, these variables are exogenous, i.e., they do not directly affect firms' export growth, but only through the contemporaneous improvements in road infrastructure.

The ordinary least squares estimate of the coefficient of interest is positive and statistically different from zero. Noteworthy, this coefficient is also positive and significant after purging out all variation in the data that is uncorrelated with the instruments. In particular, according to the instrumental variables point estimate, the rate of growth of those exports whose routes to the main port experienced a reduction in their length due to the construction of new roads has been 39.8% higher ($(e^{0.335}$-1)x100=39.8) than that of their counterparts whose route length remained the same over the period 2003-2010.[28] Given that the average (logarithmic) distance traveled to the exit point would have decreased by 22.0% for the former

[25] Even though the treatment variable is binary, a linear model is used to estimate the first-stage equation. The reason is that linear 2SLS estimates have a robust causal interpretation that is insensitive to the possible nonlinearity of the first-stage conditional expectation function (see Angrist, 2001, 2006)

[26] The correlation between the two instruments is -0.11 (-0.38 when in logarithms).

[27] This critical value corresponds to the bias cutoff method for a10% maximal bias.

[28] In assessing the significance of the effects, we use heteroscedasticity-consistent standard errors. The result is robust to using alternative clusterings such as province-sector ISIC 2 digit (ISIC 4 digit) or municipality-sector ISIC 2 digit (ISIC 4 digit) and their combination with destination or ports. Moreover, estimations based on an alternative sample that excludes neighboring countries Chile and Ecuador (see Section 3) yield essentially the same results. These results are available from the authors upon request.

trade flows, the estimated instrumental variables coefficient implies that the distance elasticity of export would be 1.8.[29] This is larger than the estimate reported in Volpe Martincus and Blyde (2013). In this sense, it is worth mentioning that, while their estimate is based on a two years period and can therefore be seen as a short run response, ours results come from data covering an eight years period and can thus better seen as longer term response. This elasticity is also larger than that estimated by Duranton et al. (2013). Note, however, that their estimates correspond to domestic trade and are obtained from data at a higher aggregation level (i.e., region-pair level instead of firm-product-country level). Moreover, unlike these previous studies, our estimated elasticity informs the effect of new roads as opposed to existing roads (or their disappearance) in a country with much more limited transport infrastructure.

A simple back-of-the-envelope calculation reveals that, in the absence of changes in domestic road infrastructure, total exports would have been roughly 20% smaller in 2010. Taking into account that annual average public investment in road infrastructure over the period 2003-2010 was approximately USD 895 million, this implies that each dollar invested in infrastructure would have generated near eight additional dollars in terms of exports only in 2010.[30]

It should be noted that the estimated instrumental variables coefficient is larger than the estimated ordinary least squares coefficient.[31] This is exactly the opposite to what one would expect if the only source of endogeneity of new roads to exports is that these roads were built to serve regions with firms that were presumed to be able to expand more their foreign sales. There, instrumentation would yield estimates that would be smaller than the ordinary least squares estimates.

Several reasons could potentially explain the observed discrepancy between those estimates (see Baum-Snow, 2007; and Duranton and Turner, 2012). First, the difference might reflect classical measurement errors in the road infrastructure variable. Given the use of precisely geo-referenced data this is unlikely to be the case. Further, while first-differencing to eliminate fixed effects generally magnifies the importance of measurement error biases (see, e.g., Arellano, 2003), this is less a concern here because longer differences (i.e., 2003-2010) are taken (see, e.g., Griliches and Hausman, 1986).

Second, the transportation infrastructure might be misspecified in the estimating equation. In particular, there might be other transport modes to ship goods from the plants to the exiting ports (e.g., railroad). If these other transport modes were relevant, they would be a missing variable in Equation (2). Further, improvements in these other transport infrastructures could have been associated with larger export growth and smaller road expansion over the sample period, in which case our transport infrastructure variable could be negatively correlated with the error term. Nevertheless, this does not

[29] This estimated elasticity is within the range of infrastructure elasticities estimated using instrumental variables considered in the meta-analysis conducted by Celbis et al. (2013).
[30] This figure should be seen as a lower bound as only a portion of the aforementioned resources was actually invested in the construction of new roads. Part of these resources was allocated to maintenance, repairing, and rehabilitation of roads.
[31] The same results' pattern holds in several related studies (see, e.g., Baum-Snow, 2007; and Duranton et al., 2013).

appear to be an issue here as road transportation is the prevailing transport mode in Peru with an approximate share in total cargo shipped of 95% (see MTC, 2007). Having said that, we should mention that there are specific sectors for which alternative modes account for a non-negligible and even relatively important portion of their goods' total cargos. This is primarily the case with natural resources and specifically with minerals and metals (see MTC, 2005). Notice, however, that the gap between the instrumental variables and the ordinary least squares estimates remains essentially the same when we re-estimate Equation (2) on the sample of differentiated products (see Columns 3 and 4 in Table 1). More generally, these latter estimation results also corroborate our baseline, thus further suggesting that our findings do not only concern trade in agricultural goods or minerals and metals as one might be *a priori* tempted to think of a developing country such as Peru and have broader their external validity.[32]

Third, the variables related to the Inca road network might be specifically better at predicting road constructions that are important for exports. However, the estimated coefficient of the first-stage equation as estimated on the subsample of exporting municipalities does not significantly differ from the counterpart estimated on the subsample of never exporting municipalities.[33] Moreover, the road network in Peru consists of national and departmental routes, which have different purposes. Thus, national routes interconnect the country longitudinally and transversely to allow for transport and commercial links with neighboring nations, connect the department's capital with each other and the main production and consumption centers, and articulate national and international ports and airports as well as railways, whereas the departmental routes link the departmental capitals with the provincial capitals, each of these capitals with each other, and municipalities in different provinces enabling the circulation of people and goods at the regional level, and articulate regional ports and airports (see MTC, 2005, 2010, 2011, and Zecerrano Mateus, 2011). Clearly, national roads play a more important, direct role for foreign trade. We therefore alternatively assess this last explanation of the gap between the estimated coefficients on the variable of interest according to the instrumental variables and ordinary least squares methods by re-estimating Equation (2) on a sample that excludes all observations with new national road segments. Also in this case, these estimates and their gap do not significantly differ from the baseline.[34]

Fourth and given the discussion above, it might just simply be the case that roads constructed at random have had a greater effect on trade than those built in response to regional export performance. This might be at least partially because exogenous routes were generally constructed before endogenous roads.

We next go through several robustness checks. First, in our basic specification increased road infrastructure is captured by a binary indicator. Thus, the estimated coefficient on this variable gives the

[32] By restricting the sample in this way, we are excluding commodities that are more likely to have existed and have been domestically shipped in the past (e.g., in the colonial era or even before).
[33] These estimation results are not presented here but are available from the authors upon request.
[34] These estimation results are not presented here but are available from the authors upon request.

effect associated with the infrastructure treatment status. Assuming that the intensity of this treatment can be proxied with the change in raw distances to the main port between 2003 and 2010 as computed according to the method referred to above, we can re-estimate Equation (2) using this plain distance change as the main explanatory variable. Estimates of this modified equation are presented in the first two columns of Table 3. Noteworthy, the direct estimated distance elasticity is very similar to that implied by our baseline estimation results.[35]

Second, it might be well argued that companies endogenously choose their location based on predictions of new roads such as ours. This could more likely the case and to make more economic sense, the shorter is the time gap between their establishment and the actual construction of roads. Hence, a natural way to assess whether endogenous location affects our results if to re-estimate Equation (2) on a sample of firms that were created several years prior the building of the new roads. Thus, in so doing, we specifically remove from the sample all exports originated from companies that started to operate less than five years or less than 10 years before the beginning of the period we focus on. Estimates based on these alternative samples are in line with those shown here.[36]

Third, new roads may have facilitated not only exporting, but also sourcing of inputs used to produce the goods that are sold abroad. Thus, to the extent that this is not fully controlled for by the set of fixed effects (see also below), our estimates would be capturing the direct effects of transport infrastructure on exports plus its impact on input sourcing. We therefore restrict the estimating sample to those firms whose increases in import values, import quantities, number of imported products, number of origin countries, and number of entry ports between 2003 and 2010 were below the respective medians. Results from this estimation are shown in the third and fourth columns of Table 3. These results do not significantly differ from the baseline.

Fourth, to investigate to extent our findings are sensitive to changes in the set of instruments we sequentially add three district-level instrumental variables, the altitude of the capital, the difference between the altitude of this city and that of the port, and the year of foundation of the district in which the firm is located. These variables can affect the likelihood of road infrastructure improvements for engineering and political reasons, respectively. Estimates based on these alternative instruments, which are presented in columns five to seven of Table 3, confirm our initial results.[37]

Fifth, if our identification strategy is correct, we should not see differences in export in absence of changes in road infrastructure. The most recent road inventory in Peru indicates that there are currently

[35] Admittedly, besides the construction of new roads that allowed for such a decline in plain distances, existing roads may have been improved over the sample period, which could also lead to a reduction in the effective distances to the main ports (see Volpe Martincus et al., 2012b). Notice, however, that results do not change when these improvements as well as roughness and elevation of terrain are taken into account. These results are available from the authors upon request.

[36] These estimates are available from the authors upon request.

[37] According to the first stage results, construction of new roads is less likely between cities located at significantly different altitudes. This is consistent with evidence presented in Ramcharan (2009).

more than 2,000 kilometers of projected national roads (i.e., roughly 10% of the total length of the national road network) (see MTC, 2011). We exploit these geo-referenced data to perform a placebo test whereby we assume that these and other departmental projected roads were built between 2003 and 2010 and accordingly create an artificial treatment group within our original control group.[38] Estimates of Equation (2) on this sample are reported in the left panel of Table 4.[39] These estimates show no evidence of spurious effects. In addition, using export data for 1999 we carry out an alternative placebo exercise in which we assume that the new roads were constructed between 1999 and 2002 instead of between 2003 and 2010. This amounts to test whether exports shipped along shorter routes and exports whose routes did not change in more recent years followed parallel trends before the new roads were constructed. Estimation results are shown in the right panel of Table 4. Notice that, for comparison purposes, we include estimates for the period 2003-2010 when we restrict the sample to those firm-product-country triples that are also present in the former sample. According to these results, no pre-policy differences in trajectories appear to have prevailed either.

Sixth, admittedly, other, so far omitted, factors may have played a role in explaining the expansion of firms' foreign sales. These may have grown because of increased firm productivity or because of larger demand for particular goods from particular importing countries associated with a decline in the respective transport costs or tariffs applied thereon (see, e.g., Volpe Martincus and Blyde, 2013). Further, firms exposed to infrastructure improvements may have also received support from Peru's national export promotion organization –PROMPERU- to participate in trade missions and international marketing events leading to foreign sales, in which case we would be overestimating the effect of interest (see, e.g., Volpe Martincus and Carballo, 2008). In order to isolate these additional potential confounders and hence check the robustness of our previous estimation results, we expand the set of fixed effects included in the equation estimated on the disaggregated export data along the respective dimensions. More precisely, we also estimate alternative specifications in which we include firm fixed effects, destination and product fixed effects, and product-destination fixed effects, and their combination.[40] Instrumental variables estimates of these augmented export equations are reported in Table 5 along with their first stage counterparts and the relevant test statistics. Reassuringly, these estimates essentially corroborate our initial findings based on the baseline specification.[41]

[38] In identifying the impact of India's railroad network on a series of economic outcomes, Donalson (2013) also carries out placebo exercises using approved construction plans that were never actually built. Jedwab and Moradi (2013) also do so in their study on Ghana.

[39] Needless to say, exports whose distances to the respective ports actually declined are not included in this sample.

[40] The product-destination fixed effects are also likely to account for potential export spillovers from firms with improved road connections with their main ports to peers without changes in these connections, thus mitigating the risk of underestimating the effect of interest.

[41] There might have occurred shocks to input provision that might have differential effects on production across goods or changes in firms' competencies across them. Unfortunately, we cannot estimate the specification including firm-product and product-destination fixed effects because this model is overparametrized. More specifically, such a specification would imply to incorporate

Our data also allow us to explore the channels through which this effect arises. In particular, we estimate the impact of new roads on the quantity (weight) shipped, the unit values, the number of shipments, and the average value and quantity per shipment, based on Equation (2). Estimation results are presented in the first two columns of the upper panel of Table 6. These results reveal that expansion in transport infrastructure, by leading to decreased distances to ports and therewith to lower transport costs, has translated into an increasing number of shipments and thereby into growing quantities shipped, but has not influenced the unit values or the size of the shipments.

So far, we have primarily focused on the export intensive margin (i.e., continuing flows). Increased transport infrastructure might have also helped some firm start exporting. Hence, we also examine the effect of changes in available roads on the firm export extensive margin by estimating a linear probability model paralleling Equation (2) in which the dependent variable is a binary indicator that takes the value of one if the firm began to export in 2010 and zero otherwise, on the sample of active firms belonging to tradable sectors (i.e., primary and manufacturing) that did no export in 2003.[42] Estimation results are reported in the lower panel of Table 6. According to these results, road infrastructure innovations do not seem to have had a significant impact on entry.[43] This is confirmed when we estimate Equation (2) on data at the municipality-sector ISIC 4-digit-product-destination level and use as a dependent variable the number of firms exporting a product to a destination in a given municipality-sector pair (see Table 7).[44] We now turn to the effect of exports on employment.

5 From Exports to Employment

The previous section has established that improved domestic road infrastructure is associated with increased firms' exports. In this section, we build upon these findings therein to explore to what extent these increased exports lead to employment growth.[45] There are important challenges to identification of a causal relationship between these variables as several factors can affect firms' employment. Despite these potential limitations, we believe that this byproduct analysis can provide interesting insights on the

9,083 fixed effects, which is more than the number of observations. Nevertheless, we believe that the estimation results shown in Table 5 provide convincing evidence that road infrastructure improvements have positively affected exports.

[42] The main explanatory variable is, as before, the binary indicator of changes in available transport infrastructure. Initial and final routes of these non-exporting firms are primarily identified based on the main ports used by their exporting counterparts that belong to the same ISIC-4 digit sector and are located in the same province.

[43] We have also investigated whether there are heterogeneous effects across regions and types of goods by estimating a modified version of Equation (2) in which we allow for these differential impacts through the incorporation of proper interactions. Estimates based on this alternative specification indicate that effects are stronger for heavier goods (i.e., goods whose initial weight to value ratio are above the median) and from more distant locations (i.e., origins whose distance to the main customs are above the median). These estimation results are available from the authors upon request.

[44] An entire set of tables paralleling those included in this document that report estimates obtained using data at the municipality-sector-product-destination level is available from the authors upon request.

[45] Unfortunately, we do not have firm-level data on production or sales.

broader economic (non-strictly trade) implications of infrastructure investments as typically argued in national export plans.

In carrying out this analysis, we assume the following empirical model of employment:

$$lnL_{frst} = \beta lnX_{frst} + \gamma_{frs} + \pi_{rst} + \upsilon_{frst} \quad (4)$$

where L corresponds to the firms' number of employees and X to firms' export volume. The remaining terms of Equation (4) are control variables. Thus, γ_{frs} is primarily a set of firm fixed effects that captures, for instance, firm's productivity and other firm-level factors that are constant over time; π_{rst} is a set of region-sector-year fixed effects that controls for employment changes in firms located in specific regions and belonging to specific sectors that might potentially be related to certain regional or sectoral characteristics directly correlated with the distance to or the distance that could have been traveled on the Inca Roads or with determinants of their geographical location, thus causing a violation of the exclusion restriction, as well as for other potential region-sector time varying factors such as labor market frictions, labor participation rates, wage differential across region-sectors, and public policies (e.g., subsidies to SMEs) aimed at promote employment in particular sectors in certain departments (see, e.g., INEI, 2011); and υ is the error term. [46]

As before, we first-differentiate Equation (4) to eliminate the firm-region-sector fixed effects. Thus, we estimate the following baseline employment equation:

$$\Delta lnL_{frs1} = \beta \Delta lnX_{frs1} + \pi_{rs}^{'} + \upsilon_{frs}^{'} \quad (5)$$

where $\pi_{rs}^{'} = \pi_{rs1} - \pi_{rs0}$ absorbs all region-sector shocks; and $\upsilon_{frs}^{'} = \upsilon_{frs1} - \upsilon_{frs0}$.

Clearly, exports can be endogenous to employment. Hence, we instrument them with the predicted values derived from our previous instrumental variables estimation of the export equation (2). Notice that, after conditioning on region-sector fixed effects, these predicted values are primarily driven by the change in road infrastructure and that, once instrumented with the distance to and on the Inca Roads, this change in infrastructure is exogenous. The implied variation in exports can then be used to identify the impact of infrastructure-related exports on employment at the firm level.

More precisely, we first compute the predicted export values for each firm-product-country from Equation (2) using the estimated coefficients reported in Table 2. These predicted values can be summed over product-destinations to arrive at a prediction for the change in firm-level exports (see, e.g., Frankel

[46] Exporting firms are formal and they accordingly are registered with the tax agency and pay taxes. Nevertheless, they might have shares of registered employees smaller than one, i.e., some of their workers might be informal. As a consequence, changes in the level of formal employment may originate from actual hiring of new employees as well as from formalization of previously informal workers. Even though the existing empirical evidence points to a complex pattern of co-movement between the degree of formalization and macroeconomic fluctuations, the former may be thought to increase when the economy is growing fast, such as in Peru over the sample period (see, e.g., Fiess et al., 2010; and Loayza and Rigolini, 2011). Hence, this might potentially explain at least part of the changes observed in the number of employees. Notice, however, that as along as changes in formality are region-sector specific, as it is most likely the case, the region-sector fixed effects included in the estimating equation would account for them. The same would also hold for changes in migration across regions.

and Romer, 1999; and Feyrer, 2009). Formally, we obtain a prediction for the total logarithmic export change for each firm as follows:

$$\Delta\widetilde{\ln X}_{frs1} = \widehat{\pi'_{rs}} + \hat{\alpha}\sum_{f,pc}\frac{x_{frspc0}}{\sum_{f,pc} x_{frspc0}} D_{fpc1} \tag{6}$$

We then use the predicted value $\Delta\widetilde{\ln X}_{frs1}$ as the instrument for actual export change in estimating Equation (5) by instrumental variables.[47] Because the first-differenced firm-level employment equation includes region-sector fixed effects, the identification comes from the within region-section variation and, hence, is not generated by these effects.[48]

Table 8 reports ordinary least squares and instrumental variables estimates of Equation (5), also accompanied in this case by the first-stage results and the specification test corresponding to the latter for years 2003-2010. In this sense, it is worth mentioning that the F test statistic as well as the under-identification test statistic validate our instrumentation strategy. The estimated ordinary least squares coefficient indicates that increased exports are indeed associated with employment growth. Importantly, the instrumental variable estimate reaffirms this conclusion. The latter specifically suggests that a 10% increase in (the rate of growth of) exports -driven by improved transport infrastructure- leads to a 4% increase in the (rate of growth of the) number of employees. This estimated elasticity is remarkably similar to that estimated in Park et al. (2010) on a sample of Chinese firms over the period 1995-2000 using exchange rate shocks as instruments for changes in exports. Like theirs, our instrumental variables estimate exceeds the ordinary least squares estimate. A possible explanation would be that the latter is biased downward due to the existence of omitted variables that lead to increased exports but have minimal or negative effects on employment. This would be for instance the case with the entry into force of a trade agreement with a major partner during the sample period, as in fact occurred with the United States, which enhances firms' access to foreign markets, thereby fostering firms' exports (see, e.g., Lileeva and Trefler, 2010). On the other hand, such an agreement simultaneously intensifies the competition these exporting firms are subject to at home, thus potentially making them experience contractions in domestic output and sales. In net terms, in this scenario, companies may be able to expand abroad, but do not necessarily register increases in their total sales and thus in their total number of employees (see, e.g., Demidova and Rodriguez-Clare, 2009).[49]

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[47] Under conditions that are met in our case as we are using predicted values from an instrumental variables estimation, it can be ignored that this instrument was estimated in using instrumental variables for inference (see Wooldridge, 2002).

[48] New Economic Geography models predict that reduce transport costs may foster labor migration across regions, which can affect local labor markets (see, e.g., Krugman, 1991). This might create a challenge to our estimation of the employments effects of exports. However, if anything, internal migration in Peru has declined over the sample period, both in relative and absolute terms (see, e.g., INEI, 2009).

[49] In the same vein, instrumental variable estimates could be larger than those of ordinary least squares because the latter confound the effects of labor supply and demand shifts, which results in a downward bias in the estimated effect of demand on market outcomes (see, e.g., Bound and Holzer, 2000).

An alternative reason would be classical measurement error. However, in our case, this is unlikely to play an important role in accounting for the difference between estimated instrumental variables and ordinary least squares coefficients. To show why, we re-estimate the instrumental variables regression using the logarithmic change of exports over an alternative sub-period (e.g., 2003-2006) as the instrument instead of the predicted value from Equation (2). Nonetheless, the instrumental variable estimates do not turn out to be larger than the ordinary least squares estimates as it would be expected if attenuation bias driven by measurement errors would prevail (see Park et al., 2010).[50]

The baseline estimation of the employment equation has the main limitation that we cannot formally show that the exclusion restriction is not violated. This may be a reason for concern because, arguably, our instruments in the export equation might potentially have a direct effect on employment even after conditioning by region-sector fixed effects. We address this concern by re-estimating Equation (5) using as an additional instrument the weighted average change in the GDP of exporting firms' destination countries between 2003 and 2010 where the weights are the share of these countries in the firms' total exports in the initial year.[51] Results from this estimation are reported in the second column of Table 9. These results are in line with those discussed above and, importantly, all specification tests, including the Hansen test for overidentifying restrictions, speak in favor of the validity of our strategy.[52]

In addition, we also assess the robustness of our estimation results by exploring the mechanisms through which exports affect employment. Thus, the employment responses associated with a given export expansion driven by increased transport infrastructure are more likely to be larger for firms belonging to labor intensive sectors. In fact, this is precisely what we observe in the fourth column of Table 9, which presents the results obtained when Equation (5) is re-estimated on the sample of companies within sectors that intensively use labor.[53] More specifically, the estimated effects are larger than the respective baseline.[54]

In closing, we use the previous estimations along with the firm-level data at hand to provide some quantification of the impact of road infrastructure on employment. First, firms-product-destinations that

[50] These results are available from the authors upon request.

[51] This instrumenting strategy is similar in spirit to that implemented by Park et al. (2010) who use the change in destination countries' exchange rates weighted by the share of these countries in initial firms' total exports as an instrument for exports when estimating their effects on other firms, performance variables such as employment.

[52] The estimated employment equation and the overidentification test in particular would suggest that new roads have primarily affected employment through their impact on exports rather than through domestic demand. This may be the case if relatively good roads were already available to sell in Peruvian main economic centers such as Lima, but those recently constructed also made it possible to sell more abroad. In fact, according to production data from the 2008 National Economic Census and trade data from the customs, goods shipped along these roads tend to belong to sectors with higher export shares in their production values.

[53] We use the classification proposed by Leamer (1984) in identifying labor intensive sectors. In so doing, given that the Peruvian tax agency SUNAT utilizes the ISIC Revision 3 classification for registered companies in the country, we have first mapped the original SITC Revision 2-based classification into an ISIC Revision 3-based classification.

[54] We should mention, however, that when estimating a modified version of Equation (5) that allows for different effects of exports on labor for labor intensive sectors and non-labor intensive sectors through an interaction term, the estimated coefficient on the former is larger than that on the latter, but they do not seem to significantly differ from each other. These alternative results are available from the authors upon request.

saw their distances to the main ports reduced have registered an average (logarithmic) export growth of 93.9%. Based on the estimates of the baseline export equations, 31.5% of this growth can be attributed to domestic transport infrastructure improvements. Hence, estimations in Table 8 imply that employment would have grown by 1.1% in the aforementioned companies as a consequence of the increased exports that the construction of the new roads allowed for. Further, given that the (logarithmic) growth of the total number of employees of these companies was 54.1% and that around 30% of this growth can be traced back to increased foreign sales, this would mean that infrastructure-driven exports accounts for approximately 6.5% of the (net) new jobs that exports created between 2003 and 2010.

To sum up, our econometric results provide robust evidence that increased road infrastructure, by reducing the distance that the shipment must be transported along to the main ports and hence the incurred transport costs, translated into larger firms' export expansion and therewith seem to have actually contributed to job growth in benefited companies.

6 Concluding Remarks

Public investments in transportation infrastructure are often justified by arguing that resulting new roads or improved roads would help firms expand their exports. Larger foreign sales would then foster job growth. However, whether and to what extent this presumption finds support in reality is virtually unknown. In this paper, we address this relevant policy question, thereby filling a notorious gap in the literature. We primarily examine the effects of new roads constructed in Peru between 2003 and 2010 on Peruvian firms' exports. In addition, we explore the subsequent impact on employment. In so doing, we exploit a rich dataset consisting of the universe of export transactions in these years and detailed geo-referenced information on the road network. Also important, we account for potential endogeneity of new road infrastructure by resorting to an instrumental variables approach, whereby the distance from each geographical origin to the nearest Inca road and the distance that could have been traveled along the Inca road network to the exiting ports are used as instruments. Results based on this empirical approach suggest that new roads have made possible increased firms' exports. Further, this deepened penetration of foreign markets seems to have in fact been associated with higher employment.

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Table 1

Aggregate Export Indicators		
Indicators	**2003**	**2010**
Total Exports	9,040.7	35,734.7
Number of Exporting Firms	5,101	7,518
Number of Destinations	168	180
Number of Exported Products	3,918	4,533
Number of Shipments	304.6	739.7
Number of Ports	18	18
Number of Firms with Reduced Distance to Customs		1,561
Average Exporter		
Total Exports	1,772.3	4,753.2
Number of Destinations	2.6	2.7
Number of Exported Products	7.4	8.1
Number of Shipments	59.7	98.4
Number of Ports	1.2	1.2
Distance to Ports	237.2	209.0
Employment	122.6	108.7

Source: Authors' calculations based on data from SUNAT.

Total aggregate exports are expressed in millions of US dollars. Average firm total exports are expressed in thousands of US dollars. Average distance to ports is expressed in kilometers. Distances to ports are computed only over those firms that register exports in both years.

Table 2

The Impact of New Roads on Firms' Exports, 2003-2010
OLS and IV Estimates

	All Products		Differentiated Products	
	OLS	**IV**	**OLS**	**IV**
D	0.216**	0.335**	0.267**	0.446***
	(0.096)	(0.158)	(0.108)	(0.168)
Region-Sector Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.041		0.042	
First Stage Estimates				
Distance to the Inca Road		-0.258***		-0.585***
		(0.047)		(0.062)
Distance on the Inca Road		0.063***		0.075***
		(0.002)		(0.004)
Region-Sector Fixed Effects		Yes		Yes
F-Statistic		420.384		311.360
		[0.000]		[0.000]
KP Test Statistics		861.485		638.150
		[0.000]		[0.000]
Hansen Test Statistic		0.782		0.464
		[0.376]		[0.496]
Adjusted R^2		0.341		0.487
Observations	7,909	7,909	5,415	5,415

Source: Authors' calculations based on data from SUNAT.

The table reports OLS and IV estimates of Equation (2) along with the first stage estimates and the relevant specification test statistics for the latter, for both all products and differentiated products. Goods are classified using the conservative version of the classification proposed by Rauch (1999). The dependent variable is the change in the natural logarithm of export value at the firm-product-country level between 2003 and 2010. The main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. In the instrumental variables estimation, the latter is instrumented with the distance from the geographical origin of the export flow to the nearest Inca road and the distance that could have been traveled along the Inca road network from this origin to the port through which the firm exports the product to the destination country. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 3

The Impact of New Roads on Firms' Exports, 2003-2010
Robustness Checks: Continuous Distance, Placebo, Imports, and Alternative Instruments
OLS and IV Estimates

	Continuous Distance		Imports		Other Instruments		
	OLS	**IV**	**OLS**	**IV**	**IV**	**IV**	**IV**
D	0.717***	2.079**	0.123	0.346*	0.397**	0.376**	0.287**
	(0.283)	(0.926)	(0.093)	(0.182)	(0.155)	(0.156)	(0.124)
Region-Sector Fixed Effects		Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R²	0.043		0.045				
First Stage Estimates							
Distance to the Inca Road		-0.020*		-0.218***	-0.313***	-0.307***	-0.192***
		(0.011)		(0.050)	(0.055)	(0.055)	(0.045)
Distance on the Inca Road		0.012***		0.063***	0.065***	0.065***	0.055***
		(0.001)		(0.002)	(0.002)	(0.002)	(0.002)
Altitude of the District Capital					-0.035***	-0.036***	
					(0.005)	(0.005)	
Difference of Altitude District Capital-Port							-0.058***
							(0.003)
Year of District Foundation						-0.323***	-0.315***
						(0.084)	(0.074)
Region-Sector Fixed Effects		Yes		Yes	Yes	Yes	Yes
F-Statistic		217.713		341.960	280.292	214.278	624.103
		[0.000]		[0.000]	[0.000]	[0.000]	[0.000]
KP Test Statistic		446.154		702.960	861.456	878.231	2,557.921
		[0.000]		[0.000]	[0.000]	[0.000]	[0.000]
Hansen Test Statistic		0.337		0.640	2.843	4.187	2.998
		[0.561]		[0.424]	[0.241]	[0.242]	[0.392]
Adjusted R²					0.360	0.359	0.456
Observations	7,901	7,901	6,492	6,461	7,870	7,860	7,860

Source: Authors' calculations based on data from SUNAT.

Columns 1 and 2 of the table report OLS and IV estimates of an alternative specification of Equation (2), in which the main explanatory variable is the change in the natural logarithm of the distance to the main port at the firm-product-country level between 2003 and 2010. Columns 3 and 4 of the table present OLS and IV estimates of Equation (2) when the estimating sample is restricted to those firms whose increases in import values, import quantities, number of products imported, number of origin countries, and number of entry customs over the period 2003-2010 were below the respective medians. In all cases, the dependent variable is the change in the natural logarithm of export value at the firm-product-country level between 2003 and 2010. In columns 3 to 7, the main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. In the instrumental variables estimations whose results are shown in columns 1 to 4 the latter is instrumented with the distance from the geographical origin of the export flow to the nearest Inca road and the distance that could have been traveled along the Inca road network from this origin to the port through which the firm exports the product to the destination country. In those estimations whose results are reported in columns 5 to 7 the altitude of the capital of the district, the year of foundation of the district in which the firm is located, and the difference in the altitude of the capital of the district and the main port are incorporated as additional instruments. All IV estimates are accompanied by their respective first stage estimates and the relevant specification test statistics. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Page 4

The Impact of New Roads on Firms' Exports, 2003-2010
Robustness Checks: Placebos
OLS and IV Estimates

	Non-built Roads Assumed as Built Roads				Pre- vs. Post-Road Construction Periods			
	Binary Indicator		Continuous Distance		1999-2002		2003-2010	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
D	0.243	2.668	0.595	7.297	-0.094	-0.005	0.298**	0.468**
	(0.213)	(1.737)	(0.446)	(5.334)	(0.098)	(0.184)	(0.117)	(0.232)
Region-Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.041		0.039		0.066		0.095	
First Stage Estimates								
Distance to the Inca Road		-0.009		-0.005		-0.368***		-0.302***
		(0.019)		(0.007)		(0.081)		(0.100)
Distance on the Inca Road		0.010***		0.003***		0.056***		0.056***
		(0.002)		(0.001)		(0.004)		(0.004)
Region-Sector Fixed Effects		Yes		Yes		Yes		Yes
F-Statistic		17.508		9.551		176.874		140.749
		[0.000]		[0.000]		[0.000]		[0.000]
KP Test Statistic		35.911		19.580		372.761		298.376
		[0.000]		[0.000]		[0.000]		[0.000]
Hansen Test Statistic		1.099		1.099		0.387		0.095
		[0.295]		[0.295]		[0.534]		[0.758]
Adjusted R^2		0.031		0.039		0.317		0.312
Observations	6,662	6,662	6,662	6,662	2,686	2,686	2,686	2,686

Source: Authors' calculations based on data from SUNAT.

Columns 1 to 4 of the table report OLS and IV estimates of Equation (2) when estimated on the sample of firm-product-country exports whose routes did not actually change between 2003 and 2010 and projected national departmental routes are assumed to have been constructed over this period. In Columns 1 and 2 the main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. In Columns 3 and 4 the main explanatory variable is the change in the natural logarithm of the distance to the main port at the firm-product-country level between 2003 and 2010. Columns 5 and 6 the table shows OLS and IV estimates of Equation (2) over the period 1999-2002 assuming new roads constructed between 2003 and 2010 were built in that period. Columns 7 and 8 present OLS and IV estimates of Equation (2) over the period 2003-2010 when the estimating sample is restricted to those firm-product-country triples that also existed in 1999-2002. In all cases, the dependent variable is the change in the natural logarithm of export value at the firm-product-country level between 2003 and 2010. In columns 3 to 8, the main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. In the instrumental variables estimation, the main explanatory variable is instrumented with the distance from the geographical origin of the export flow to the nearest Inca road and the distance that could have been traveled along the Inca road network from this origin to the port through which the firm exports the product to the destination country. All IV estimates are accompanied by their respective first stage estimates and the relevant specification test statistics. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 5

The Impact of New Roads on Firms' Exports, 2003-2010 Robustness Checks: Alternative Specifications IV Estimates				
	S1	**S2**	**S3**	**S4**
D	0.519**	0.787***	0.974***	0.851*
	(0.237)	(0.261)	(0.294)	(0.435)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Product Fixed Effects	No	No	Yes	No
Destination Fixed Effects	No	Yes	Yes	No
Product-Destination Fixed Effects	No	No	No	Yes
First Stage Estimates				
Distance to the Inca Road	-0.218***	-0.203***	-0.160***	-0.187***
	(0.041)	(0.047)	(0.047)	(0.072)
Distance on the Inca Road	0.055***	0.056***	0.049***	0.036***
	(0.002)	(0.003)	(0.003)	(0.006)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Product Fixed Effects	No	No	Yes	No
Destination Fixed Effects	No	Yes	Yes	No
Product-Destination Fixed Effects	No	No	No	Yes
F-Statistic	730.500	185.320	145.720	28.140
	[0.000]	[0.000]	[0.000]	[0.000]
KP Test Statistic	1403.000	512.120	352.100	170.050
	[0.000]	[0.000]	[0.000]	[0.000]
Hansen Test Statistic	2.359	1.789	0.274	0.105
	[0.124]	[0.181]	[0.602]	[0.746]
Adjusted R^2	0.286	0.268	0.835	0.139
Observations	7,901	7,901	7,901	7,901

Source: Authors' calculations based on data from SUNAT.

The table reports IV estimates of alternative specifications of Equation (2) along with the respective first stage estimates and the relevant specification test statistics. The dependent variable is the change in the natural logarithm of export value at the firm-product-country level between 2003 and 2010. The main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. In the instrumental variables estimation, the latter is instrumented with the distance from the geographical origin of the export flow to the nearest Inca road and the distance that could have been traveled along the Inca road network from this origin to the port through which the firm exports the product to the destination country. Alternative sets of fixed effects (firm; firm and product; firm, product, and destination; firm and product-destination) included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 6

The Impact of New Roads on Firms' Exports, 2003-2010 OLS and IV Estimates		
Channels		
Quantity		
	OLS	**IV**
D	0.196**	0.387**
	(0.086)	(0.162)
Unit Value		
	OLS	**IV**
D	0.020	-0.053
	(0.030)	(0.047)
Number of Shipments		
	OLS	**IV**
D	0.026	0.217**
	(0.057)	(0.096)
Average Exports per Shipment		
	OLS	**IV**
D	0.190***	0.117
	(0.060)	(0.121)
Average Quantity per Shipment		
	OLS	**IV**
D	0.170***	0.170
	(0.063)	(0.124)
Region-Sector Fixed Effects	Yes	Yes
Observations	7,901	7,901
Firm Export Extensive Margin		
	OLS	**IV**
D	-0.007	0.036
	(0.013)	(0.27)
Region-Sector Fixed Effects	Yes	Yes
Adjusted R^2	0.031	
First Stage Estimates		
Distance to the Inca Road		-0.146***
		(0.032)
Distance on the Inca Road		0.066***
		(0.003)
Region-Sector Fixed Effects		Yes
F-Statistic		221.118
		[0.000]
KP Test Statistics		196.928
		[0.000]
Hansen Test Statistic		0.001
		[0.973]
Adjusted R^2		
Observations	9,681	9,681

Source: Authors' calculations based on data from SUNAT.
The upper panel of the table reports OLS and IV estimates of Equation (2). The dependent variables are the change in the natural logarithm of export value, export quantity (weight), unit value, number of shipments, average exports per shipment, and average quantity (weight) per shipment at the firm-product-country level between 2003 and 2010. The main explanatory variable is a binary variable that takes the value of one if the distance over which a firm shipped their products to their main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. The lower panel of the table reports OLS and IV estimates of a modified version of Equation (2). The dependent variable is a binary indicator that takes the value of one if a firm exported in 2010 and zero otherwise. The main explanatory variable is a binary variable that takes the value of one if the distance over which a firm could ship their products to their (potential) main port when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. Initial and final routes are identified based on the customs used by exporting firms that belong to the same ISIC 4-digit sector and are located in the same province. The estimating sample consists of all active firms belonging to tradable sectors that did no export in 2003. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 7

The Impact of New Roads on Municipality-Sector Exports, 2003-2010 OLS and IV Estimates		
Channels		
Exports		
	OLS	**IV**
D	0.334***	0.672***
	(0.118)	(0.177)
Number of Firms		
	OLS	**IV**
D	0.023	0.001
	(0.016)	(0.026)
Quantity		
	OLS	**IV**
D	0.429***	0.766***
	(0.123)	(0.178)
Unite Value		
	OLS	**IV**
D	-0.095**	-0.094*
	(0.040)	(0.052)
Number of Shipments		
	OLS	**IV**
D	0.164**	0.424***
	(0.075)	(0.099)
Average Exports per Shipment		
	OLS	**IV**
D	0.170**	0.248*
	(0.083)	(0.129)
Average Quantity per Shipment		
	OLS	**IV**
D	0.265***	0.342***
	(0.091)	(0.129)
Region-Sector Fixed Effects	Yes	Yes
First Stage Estimates		
Distance to the Inca Road		-0.433***
		(0.052)
Distance on the Inca Road		0.075***
		(0.002)
Region-Sector Fixed Effects		Yes
F-Statistic		824.771
		[0.000}
KP Test Statistics		1,681.345
		[0.000]
Hansen Test Statistic		0.913
		[0.340]
Adjusted R^2		0.526
Observations	8,126	8,126

Source: Authors' calculations based on data from SUNAT.

The table reports OLS and IV estimates of Equation (2). The dependent variables are the change in the natural logarithm of export value, number of exporting firms, export quantity (weight), unit value, number of shipments, average exports per shipment, and average quantity (weight) per shipment at the municipality-sector ISIC 4-digit-product-country level between 2003 and 2010. The main explanatory variable is a binary variable that takes the value of one if the distance over which firms in a given municipality-sector shipped their products to their main customs when exporting to a given country declined between 2003 and 2010 as a consequence of the new roads built in this period and zero otherwise. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 8

The Impact of Exports on Employment, 2003-2010 OLS and IV Estimates		
	OLS	**IV**
ΔX	0.234**	0.373**
	(0.022)	(0.187)
Region-Sector Fixed Effects	Yes	Yes
Adjusted R^2	0.254	
First Stage Estimates		
Predicted Exports		0.109***
		(0.041)
Region-Sector Fixed Effects		Yes
F-Statistic		11.855
		0.000
KP Test Statistic		12.855
		0.000
Adjusted R^2		0.420
Observations	982	982

Source: Authors' calculations based on data from SUNAT.

The table reports OLS and IV estimates of Equation (4) along with the first stage estimates and the relevant specification test statistics for the latter. The dependent variable is the change in the natural logarithm of a firm's number of employees between 2003 and 2010. The main explanatory variable is the change in the natural logarithm of a firm's exports between the same years. In the instrumental variables estimation, the latter is instrumented with the predicted value of this change as estimated by instrumental variables based on Equation (2). Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

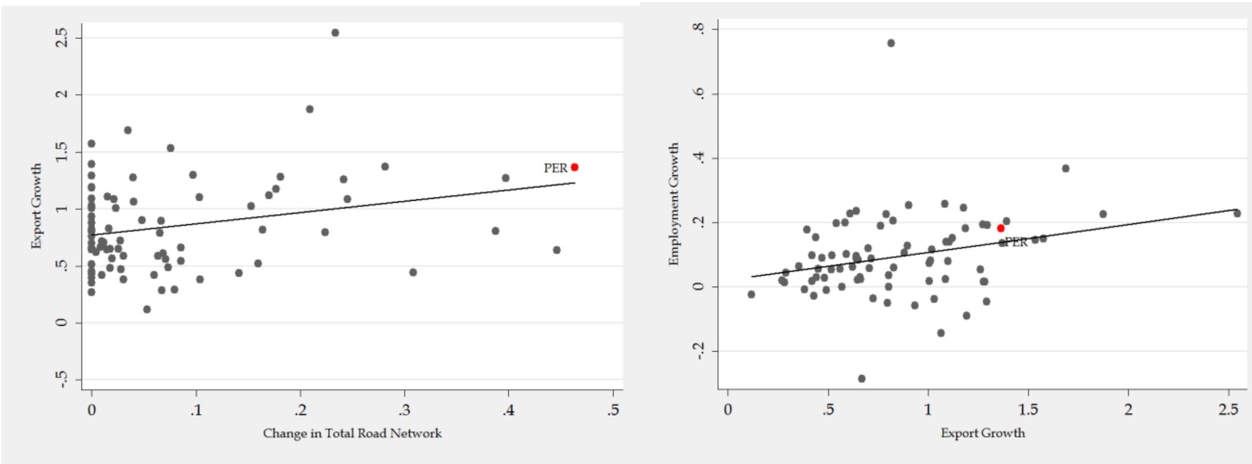
Table 9

The Impact of Exports on Firms' Employment, 2003-2010 Robustness Checks OLS and IV Estimates				
	(1)	(2)	(3)	(4)
	Other Instruments		Labor Intensive Sectors	
	OLS	IV	OLS	IV
D	0.234**	0.296***	0.257***	0.398***
	(0.022)	(0.091)	(0.041)	(0.100)
Region-Sector Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R²	0.254		0.283	
First Stage Estimates				
Predicted Exports		0.113***		0.195***
		(0.042)		(0.072)
GDP Destination Change 2003-2010		2.015***		2.981***
		(0.397)		(0.586)
Region-Sector Fixed Effects		Yes		Yes
F-Statistic		16.419		16.025
		[0.000]		[0.000]
KP Test Statistic		38.665		30.198
		[0.000]		[0.000]
Hansen Test Statistic		0.227		1.322
		[0.634]		[0.250]
Adjusted R²		0.488		0.094
Observations	982	982	384	384

Source: Authors' calculations based on data from SUNAT.

The table reports OLS and IV estimates of Equation (4) along with the first stage estimates and the relevant specification test statistics for the latter. The dependent variable is the change in the natural logarithm of a firm's number of employees between 2003 and 2010. The main explanatory variable is the change in the natural logarithm of a firm's exports between the same years. In the instrumental variables estimation, the latter is instrumented with the predicted value of this change as estimated by instrumental variables based on Equation (2) and the weighted average change in the GDP of firms' destination countries over the period 2003-2010, where the weighting factor is the share of each of these countries in the firms' total exports in 2003. Sectors classified as labor intensive are: extraction and agglomeration of peats; manufacture of wearing apparel; dressing and dyeing of fur; publishing, printing and reproduction of recorded media; manufacture of other non-metallic mineral products; manufacture of furniture; and others. Region (Department)-sector (2-digit ISIC) fixed effects included (but not reported). Robust standard errors reported in parentheses below the estimated coefficients. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Figure 1
Relationship between the Change in the Length of the Road Network and Export Growth and between Export Growth and Employment Growth



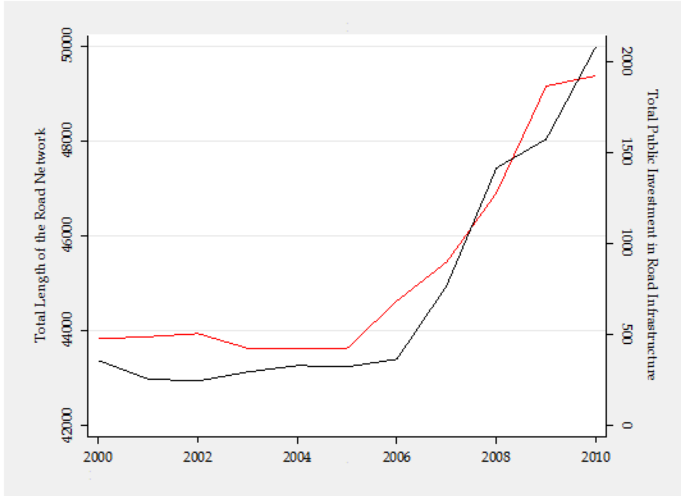
Source: Authors' calculations based on data from WDI.

The figure on the left shows the cross-country relationship between the change in the (natural logarithm of the) total length of the road network between 2003 (or the closest year) and 2010 and the change in (the natural logarithm) of total exports over the same period. The OLS estimated coefficient on the former variable is 0.992 and is significant at the 5% level. The figure on the right shows the cross-country relationship between and the change in (the natural logarithm) of total exports between 2003 and 2010 and the change in (the natural logarithm of) total employment over the same period. The OLS estimated coefficient on the former variable is 0.086 and is significant at the 1% level.

Figure 2
Agroindustrial Santa Lucía S.A.' s Export Route

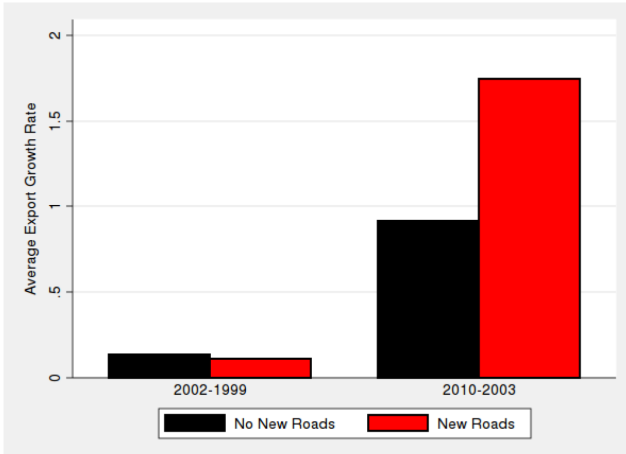
Source: Authors' calculations based on data from SUNAT, MTC, and ArcGIS.

Figure 3
Evolution of the Total Length of the Road Network and Public Investment in Road Infrastructure



Source: Authors' calculations based on data from MTC (2012) and MEF (2013).
Length is measured in kilometers (left axis). Investment is reported in millions of US dollars (right axis).

Figure 4
Average Export Growth
Municipalities with Reduced Distances to Ports vs. Municipalities with Unchanged Distances to Ports
1999-2002 and 2003-2010



Source: Authors' calculations based on data from SUNAT, MTC, and ArcGIS.

Figure 5
New Roads and Export Growth: Four Cases

Source: Authors' calculations based on data from MTC and ArcGIS.
Original routes appear in black, whereas deviations from these routes associated with new roads appear in red.

Department: La Libertad Sector: Manufacturing of Food Products			
Firm	**Reduction in Shipping Distance**	**Export Growth 1999-2002**	**Export Growth 2003-2010**
Cartavio S.A.A.	0.0	18.2	113.7
Danper Trujillo S.A.C.	28.1	15.0	145.4

Department: Lima Sector: Manufacturing of Textile Products			
Firm	**Reduction in Shipping Distance**	**Export Growth 1999-2002**	**Export Growth 2003-2010**
Inversiones Comindustria S.A.	0.0	48.1	54.7
Industrial Hilandera S.A.C.	12.7	52.5	121.2

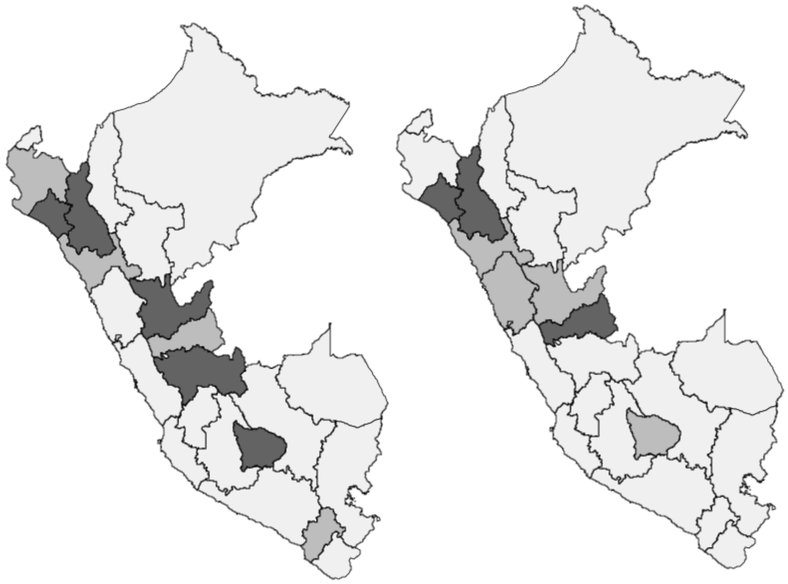
Source: Authors' calculations based on data from SUNAT, MTC, and ArcGIS.
Changes are expressed in percentage terms.

Figure 6
Road Networks in 2003 and 2010

Source: Authors' calculations based on data from MTC and ArcGIS.
The 2003 (national and departmental) road network is colored in grey, whereas the additions to this network between 2003 and 2010 are colored in black.

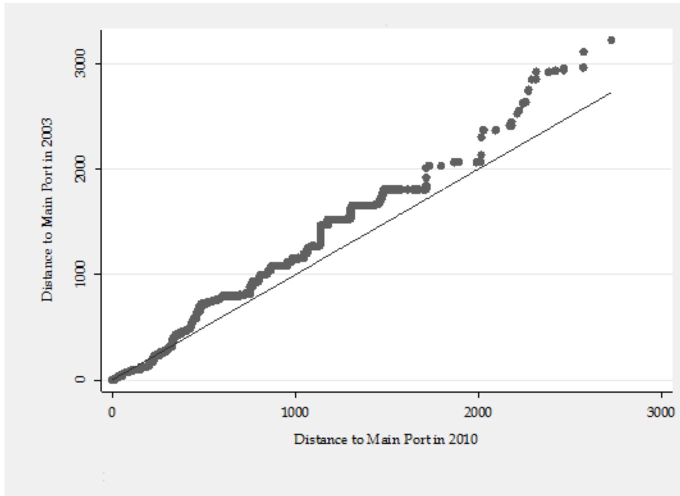
Figure 7
Spatial Distribution of the Share of Exporters with Reduced-Distance Routes (left) and The Share of Exporters with no Change in their Routes (right) across Peruvian Departments

Share of Exporters



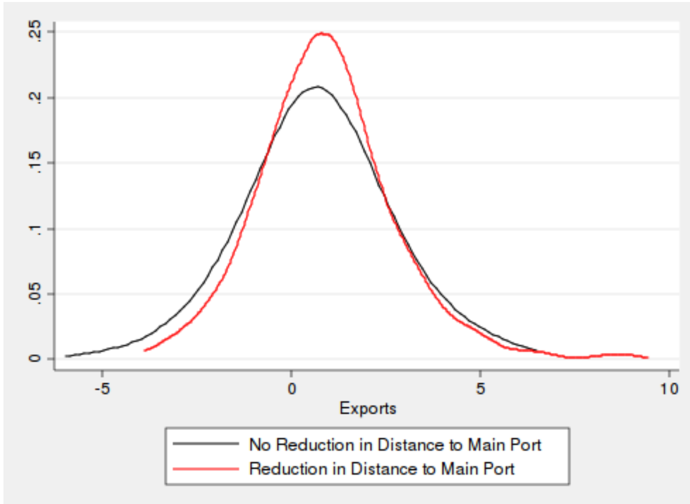
Source: Authors' calculations based on data from SUNAT, MTC, and ArcGIS.

Figure 8
Distribution of Distances to Main Ports, 2003 and 2010



Source: Authors' calculations based on MTC, SUNAT, and ArcGIS.
The figure is a quantile-quantile graph that plots the quantiles of the distances traveled (in kilometers) from the plants to the exiting ports at the beginning and at the end of the sample period for exports that are positive in both periods.

Figure 9
Distribution of Growth Rates for Exports with and without Reduced Distances to Customs, 2003-2010

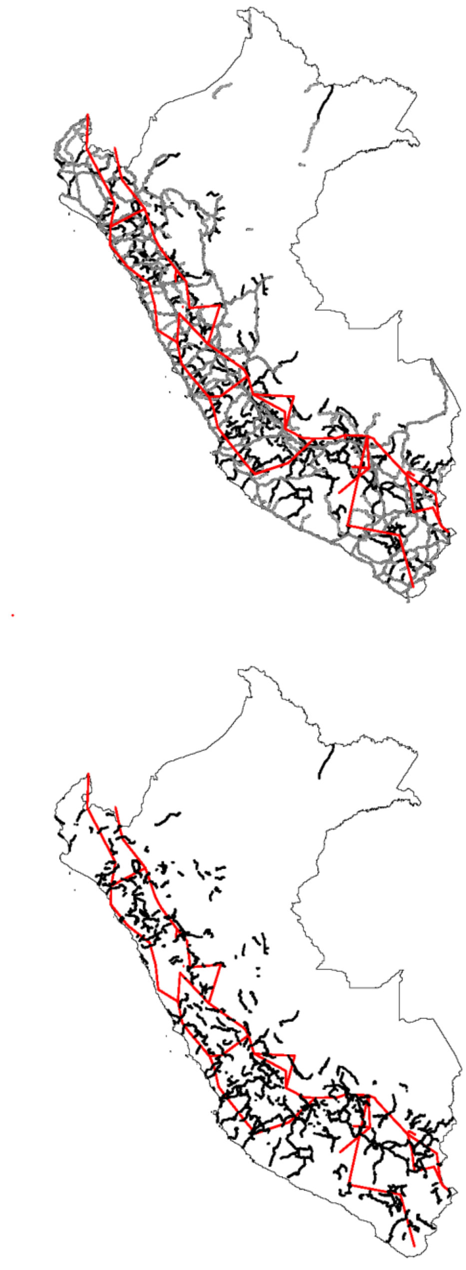


Source: Authors' calculations based on MTC, SUNAT, and ArcGIS.
The figure presents kernel density estimates of the rate of growth over the period 2003-2010 for firm-product-country exports whose distances to the respective main ports decreased as a consequence of the new roads built in this period and their counterparts whose distances to the respective ports remained the same.

Figure 10
The Inca Road Network

Source: Authors' calculations based on data from Regal (1936) and ArcGIS.

Figure 11
The Current Road Networks and the Inca Road Network



Source: Authors' calculations based on data from MTC, Regal (1936), and ArcGIS.
The 2003 (national and departmental) road network is colored in grey, whereas the additions to this network between 2003 and 2010 are colored in black. The Inca Road Network appears in red.