The Dynamics of Investment Projects: Evidence from Peru[*]

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Abstract

We present an analysis of the impact of commodity price cycles on firm investment decisions at the project level, by considering the decision of firms to delay, cancel or complete a project as initially announced. In particular, we use logit and duration models of competing risks on a novel dataset of more than 1109 announced investment projects in Peru from different economic sectors between 2009 and 2015.

Our results suggest that commodity price fluctuations are not only relevant for investment projects in the mining sector, but also create spillover effects in other sectors. Both an increase in commodity prices and a reduction in commodity price volatility reduce the probability to delay investment in the mining sector, whereas only commodity price volatility is relevant for other sectors. Under the duration analysis, probability regressions under a competing risk framework suggest that higher commodity prices lead to a higher probability of completion of investment projects in all sectors of the economy.

Key words: investment projects, panel logit, competing risks.

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1 Introduction

Large commodity price fluctuations observed in the recent decade have led policymakers to focus on the macroeconomic effects of these price swings on major commodity exporting economies. This becomes especially relevant in a period of falling commodity prices and tightening of financial conditions in advanced economies, where external factors play an important role in affecting variables such as investment, output and inflation in the short run.

Even though some countries have been better able to implement countercyclical monetary and fiscal policies to cope with these short run effects, concerns about the implications of commodity price fluctuations on long-term growth prospects remain. There is a tight link in aggregate terms between commodity price cycles and investment. One channel is through the effect of uncertainty, where the level and volatility of commodity prices affect expected returns and risk of an investment project outcome. In their recent downfall episode from 2012 to 2015, commodity prices have triggered an investment cycle in construction and infrastructure in commodity exporting countries (see BIS, 2016, chap. 3). A persistent drop in investment reduces capital formation and thus potential output.

In this work, we focus on the impact of commodity price cycles on firm investment decisions at the project level. We explore the evolution of investment projects and the decision of firms to delay, cancel or complete the project as initially announced. In particular, we focus on the effects of commodity price fluctuations on investment decisions. In order to do this, we use a novel dataset of more than 1109 announced investment projects in Peru from different economic sectors between 2009 and 2015. We track the dynamic state of these projects since their first announcement up to their cancelation or completion, as well as the expected date of completion. We create four different categories for the states of projects: confirmed, not confirmed/under revision, canceled and completed.

We analyze the effect of commodity prices on the state of the announced investment project using logit models. In the case of confirmed announced investment projects, we also consider the fact that, despite investment is still taking place, firms decide to postpone the date of termination and/or the beginning of production/operations. For this, we estimate a logit model for the probability of a delayed project and evaluate the impact of commodity price fluctuations on this decision as well.

Our main results can be stated as follows:

1. Commodity prices are highly relevant for investment project decisions by firms, not only in sectors whose profitability is directly affected by them (ie mining sector in Peru), but also create spillover effects in other sectors of the economy.

2. In the mining sector, the decision to revise an investment project is affected by both commodity price growth rates and volatility. An increase in commodity prices and lower price volatility leads to a lower probability for a project to be unconfirmed. In contrast, other sectors of the economy are only affected by commodity price volatility, where higher uncertainty creates more incentives to unconfirm or revise an investment project.

3. Once an investment project implementation is ongoing, the probability that a firm chooses to delay its completion and start production is also affected by the evolution of commodity prices.

    - For the mining sector, both commodity price growth rates and volatility matter, whereas the delay probability is only affected by volatility for other sectors.

    - An increase in commodity prices reduce incentives to delay by affecting the expected profitability of the project.

- In the case of volatility, higher uncertainty increases incentives to postpone projects for all sector of the economy. However, a second effect that is relevant in the case of the mining sector is that the possibility of better news than expected leads to higher incentives to start production and reap on the benefits of this in terms of higher profits.

4. Commodity prices do have a negative strong and statistically significant effect on the probability of project completion in all sectors. Particularly in the mining sector.

Related Literature. One strand of the literature, closely linked to our work, analyzes investment decisions from a real options approach (Dixit & Pindyck, 1994). In these works, granular data is used to analyze investment decisions, but they focus on specific sectors of the economy. For example, Bromander & Åtland (2012) analyzes sequential investments in power plants with time to build in a framework with regulatory and price uncertainty. With more regulatory uncertainty, firms prefer to invest in smaller plants whereas more price uncertainty gives incentives to complete investment projects. On the same vein, Kaldahl & Ingebrigtsen (2014) analyze a sample of gas power plants in Norway and find that both high price and regulatory uncertainties increase the probability that projects to be postponed or canceled. Our paper concentrates on price levels and their volatility in a big set of projects.

Marmer & Slade (2013) also considers time to build to study the relationship between uncertainty and investment in the decision to operate US copper mines. As opposed to standard results in the real option literature, more uncertainty lowers price thresholds, which means that high uncertainty encourages investment. The positive effect of uncertainty over investment has been stressed before in the theories of convex adjustment costs of Hartman (1972), Abel (1983) and Caballero (1991).

Also, Bloom (2009) provides more evidence on the negative association between uncertainty shocks and firm investments. At high levels of uncertainty, the real option value of inaction is high. In this circumstances firms become insensitive to other types of economic stimuli and turn very cautious. The concept of uncertainty in Bloom (2009) refers to a stochastic process of the standard deviation of business conditions linked to demand and productivity factors. In Byun & Jo (2015), Canadian manufacturing firms data are used to provide evidence that high profit uncertainty strongly harms more large and small firms than medium-size firms. Our paper is not about firm level investment decisions but about project decisions already taken and where variables like delays, cancelations are the key elements to study. Nevertheless, we also tackle other possible sources of uncertainty like environmental conflicts (political uncertainty) and possible heterogenous effects on small and big projects.

At the macro level, Fornero et.al (2015) studies the impact of commodity-price shocks in commodity-exporting countries. The key finding related to our study is the positive and delayed effect of commodity prices on investment levels and their positive spillovers in other sectors (non-commodity) of the economy. Also, Dungey et al. (2014) emphasizes the positive link between commodity price shocks and mining investment. Carrière-Swallow & Céspedes (2013) on the other hand use a measure of global uncertainty to see its effect on a sample on emerging and developed economies. In terms of investment, Carrière-Swallow & Céspedes (2013) find that a negative impact of uncertainty over investment is four times larger in emerging relative to developed countries. We complement this link between terms of trade and investment by using more granular data at the investment project level.

The duration analysis for cancelation and completion of investment is closely related to Favero et al. (1994) and Hurn & Wright (1994) who study oil fields in the UK by applying duration analysis. In Favero et al. (1994) rises in prices increase the hazard rate of undertaking the project if price uncertainty is low. In Hurn & Wright

(1994), geological and political factors account for the lag length between the decision to invest and the project implementation. Other studies that estimate hazard rates to find the negative link between uncertainty and firm investment are Pennings & Altomonte (2006) and Kellogg (2014). In our study we also estimate hazard rates but in a context of competing risk because our projects terminates due to completion or cancelation.

In the following section the paper provides a descriptive analysis of the dataset. In section 3 we detail the empirical framework, in section 4 we lay out the results and section 5 concludes.

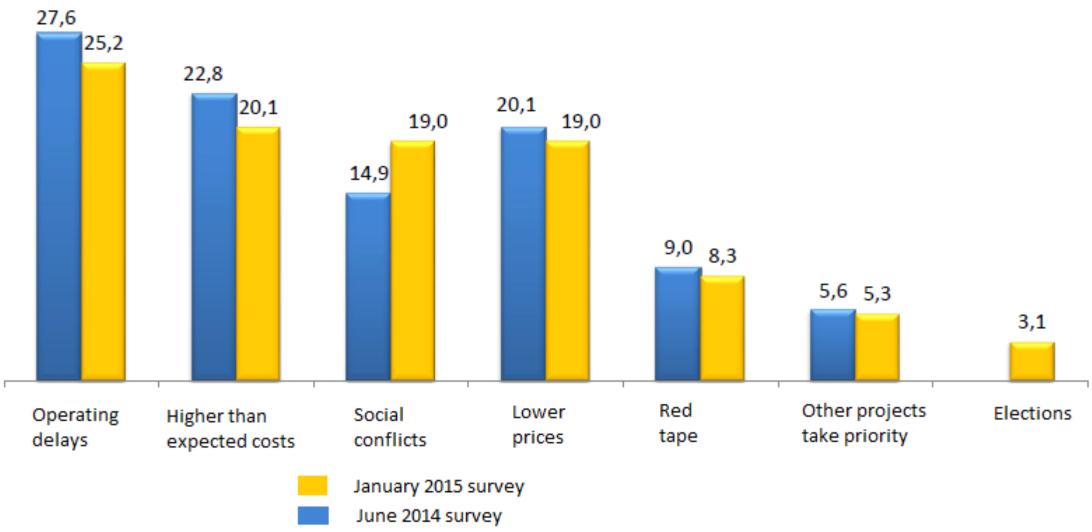
2 Descriptive analysis

The Peruvian economy is a major commodity exporter, especially in the mining sector, with metallic mining production accounting for 12 percent of GDP and mining exports representing 55 percent of total exports[1]. As the revenues of this sector are tightly linked to commodity prices, in particular to that of copper and gold, it is expected that not only ongoing production and export decisions are affected by commodity price movements, but also the decision to invest in new mining projects and in expanding current investment units.

A first reason why we expect this link between commodity prices and investment can be shown using information from the mining experts survey conducted by the Central Bank of Peru. The survey shows that a drop in commodity prices is perceived by mining sector experts as a very important cause of delays in new mining projects. Figure 1 shows the results from the three most important causes of delays in new mining projects, where 20 percent of experts consider commodity prices as one of the key reasons.

[1]This figure is calculated with data for 2015 and includes the refinement of mining products.

Figure 1. *Main causes of delay in new mining projects (in percent)*



Source: Mining experts survey. Central Bank of Peru.

In order to analyze this effect, we use a novel dataset of investment project announcements that was compiled by the Central Reserve Bank of Peru (BCRP). It considers 1109 announced projects from 2009 to October 2015. The information is obtained from media and public press releases from private firms and from surveys and interviews conducted by the BCRP. It covers investment projects in different sectors of the economy: mining, hydrocarbons, electricity, industrial, agroindustry, telecommunications and others. At each moment in time, each project is in either of four possible states: confirmed, unconfirmed, canceled or completed. We define each category as follows:

a. Confirmed projects. They have been granted permission and are about to begin implementation. This process of implementation may take some time, even years in some cases, especially for large investment projects in mining, hydrocarbons, electricity or infrastructure sectors. Once confirmed, the investor may decide to continue with its confirmed status or to revise or cancel the project. The project will change status to completed once the investor confirms the beginning of operations.

b. Unconfirmed projects. They are being considered by investors but have not began implementation or have stopped the implementation process. This state is highly linked to regulatory issues and permit requirements required for investors to begin implementation. A confirmed project might switch to unconfirmed when tighter regulatory conditions are required to be fulfilled. As shown later, very few unconfirmed projects switch back to confirmed after this.

c. Canceled projects. Investors have publicly announced that they will not continue implementation. Once canceled, the project is no longer implemented again in the sample period.

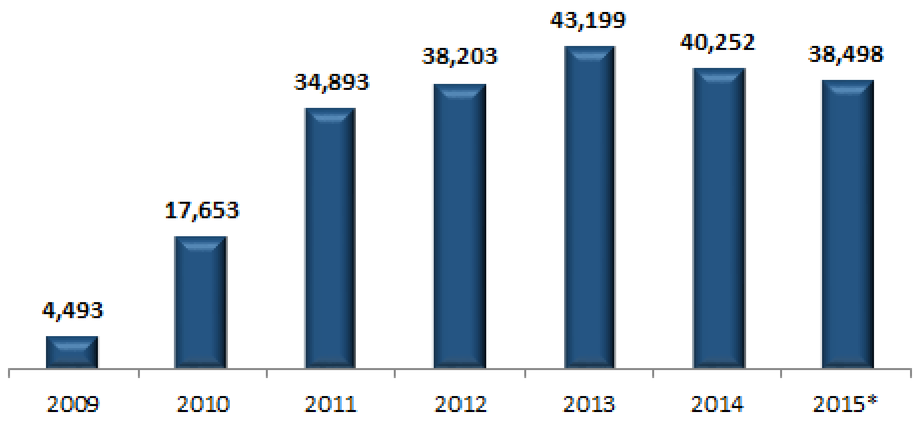
d. Completed projects. The implementation process is completed and has began operations.

It is clear that canceled and completed are absorbing states, whereas confirmed, revised and unconfirmed states may switch to each other or to one of the absorbing states. As shown in Figure 2, the amount of investment projects in the mining sector has been increasing during the period of high commodity prices, whereas it shows a slight drop in the last two years of the sample. This result partly considers the completion of some large investment projects such as Las Bambas (copper project), but also the change to unconfirmed status as well as the lack of new investment projects starting implementation.

It is also important to note that besides the large drop in aggregate investment in the last two years[2], there has also been a shift in its composition. Figure 3 shows that even though investment projects in the mining sector have contracted, the contraction in confirmed investment projects in other sectors has not been quite as large. This

[2] Aggregate private investment in Peru fell 2.1 and 4.4 percent in 2014 and 2015, respectively.

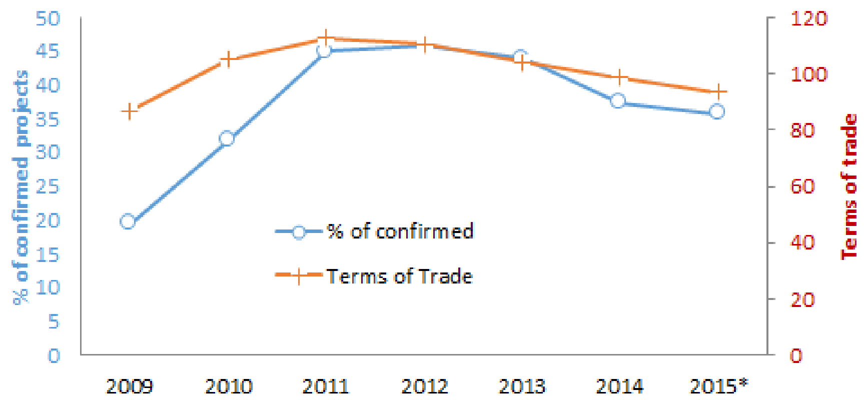
Figure 2. *Confirmed investment projects in the mining sector (in million of USD)*



Source: Central Bank of Peru.

evidence suggests that there has been some reallocation of investment from sectors directly linked to commodity exports to other sectors in the economy.

Figure 3. *Confirmed investment projects in the mining sector (as percentage of confirmed projects in all sectors)*



Source: Central Bank of Peru.

Table 1 show the transition of investment projects between possible states for two different periods: 2012, when commodity prices were relatively high and started the downward trend, and 2015, which is the last available data. What we observe is that the percentage of confirmed investment projects has declined, with a higher partici-

Table 1. *Transition between states*

Initial state ↓	Transitions in 2012			
	Confirmed	Unconfirmed	Canceled	Completed
Confirmed	56.1	0.9	1.3	5.4
Unconfirmed	0.4	18.4	0.4	0.4
Canceled	0.0	0.0	4.9	0.0
Completed	0.0	0.0	0.0	11.7
	Transitions in 2015			
	Confirmed	Unconfirmed	Canceled	Completed
Confirmed	44.5	0.0	0.6	0.9
Unconfirmed	0.0	23.2	0.0	0.0
Canceled	0.0	0.0	5.5	0.0
Completed	0.0	0.0	0.0	25.3

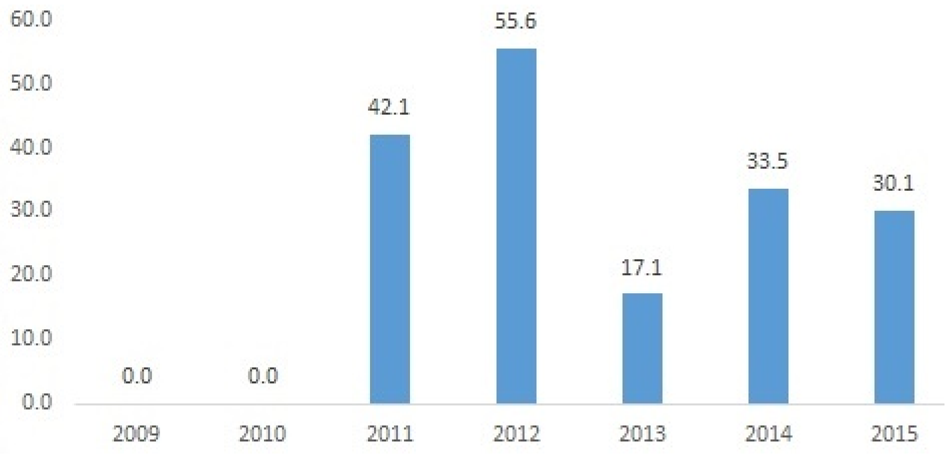
pation of unconfirmed and canceled projects. However, by looking at Table 1, we find some evidence that once commodity prices started declining, there was a change in the composition of investment strategies, with a higher concentration of projects that were transiting to a different state, besides the ones that were completed. This transition happened in both directions: considering as good news those projects that were unconfirmed and became confirmed, but also considering as bad news those which were confirmed and became unconfirmed or canceled.

In the case of confirmed projects, we also separate between the projects that suffer delays from the projects that are being implemented according to the original schedule. We track the particular months in which a firm announces a change in the completion period of the project.[3] We use this subsample of confirmed projects only to analyze the determinants of delays in investment projects. For reference, we show the evolution of delayed projects in total confirmed projects in Figure 4.

In order to analyze the determinants of the decisions to delay an ongoing investment project, first we consider qualitative information from surveys to obtain some

[3]In order to build the dummy variable for the delayed state, we will later consider different definitions.

Figure 4. *Delayed projects (as percentage of confirmed projects)*

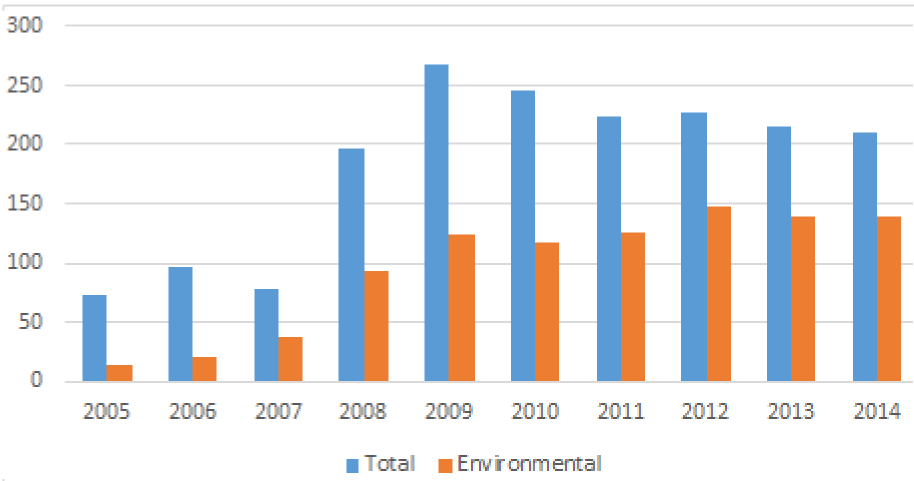


possible determinants. As shown in Figure 1 from the Survey of Mining Experts, the four main sources of delays are (i) operating delays, (ii) higher than expected costs, (iii) social conflicts and (iv) lower commodity prices. Given data availability limitations on cost structures by each firm, we further explore the evolution of social conflicts and commodity prices.

In the case of social conflicts, large investment projects are required to obtain several permits related to environmental and social concerns. The approval of these permits are tightly linked to the existence of social conflicts in the region, which either delay or create uncertainty on whether the investment project can be implemented to termination and whether the production process can take place. Figure 5 shows the number of total social and environmental conflicts in all regions of Peru during the sample period. It shows an upward trend in environmental conflicts, which in many cases are related to either ongoing or future projects related to the mining sector.

With regards to commodity prices, media and press releases show some preliminary evidence that mining companies have reduced production and delayed investment in new projects due to low commodity prices. As an example, this news from October 2015: "Glencore plans to reduce the production of zinc and suspend opera-

Figure 5. *Number of social conflicts in Peru*



Source: Peruvian Ombudsman.

tions in Peru: The main reason for the reduction is to preserve the value of Glencore's reserves in the ground at a time of low zinc and lead prices, which do not correctly value the scarce nature of our resources, the company said in a statement".[4]

3 Framework

Logit regression: An aspect of the analysis concerns the decision to delay investment decisions. In order to do this, we use a panel logit regression with fixed effects where the dependent variable, $delay_{it}$, refers to whether project i has been announced to delay its beginning of operations in time t. It takes a value of 1 if it has been announced to be delayed in the last 12 months and 0 otherwise. The estimated equation takes the following form:

$$delay_{it} = \alpha_{0i} + \alpha_1 growth_{it} + \alpha_2 volat_{it} + \alpha_3 X_{it} \tag{1}$$

Among the determinants, we consider two variables related to commodity price

[4] See Crispin & Grippa (2015) for more examples of these.

fluctuations: the year on year percentage change ($growth_{it}$) and the standard deviation of the last 12 months ($volat_{it}$) as a measure of volatility. In the case of mining projects, we consider the price of the main commodity to be extracted from each mining unit (i.e. copper, gold, silver and zinc) and for polymetallic or projects where the main mineral is not identified, we use the terms of trade index. For other sectors, we consider the terms of trade index as the commodity price for all projects.

X_{it} corresponds to a set of control variables, which include:

- $conflict_{it}$ is the number of social conflicts. In the case of mining projects, we consider the geographical location of each project, and use the number of social conflicts by region. For other sectors of the economy, we just consider the aggregate nationwide number of social conflicts.

- $financ_{it}$ is the amount of financial funding for the investment project and includes investment for all the duration of the implementation process, both the amount that has already been disbursed as well as what is expected to be required to complete the project. This variable is a proxy of the size of the investment project.

- fdi_{it} is the amount of funding that comes from foreign investors and which is categorized as foreign direct investment in the balance of payments accounts.

- $volatn_{it}$ is the volatility of commodity prices in periods of a downward trend in these prices. We add this as an extra variable to analyze if there is a differentiated effect due to uncertainty vs the willingness to speed up investment to reap on the benefits in good times.

Competing risks framework: The dataset resembles duration data, we track each project since the moment the confirmed status runs, the implementation of the confirmed project goes on until either of two terminal events or risks occur: (i) projects are completed and therefore ready to be put in operation or (ii) projects are canceled. In the dataset, some projects do not show either of these two terminal events because there is right censoring. We may only see those events if we extend the data to the future.

The implementation stage has a clear starting point, the month where it first appears in the data. It appears usually with the status of confirmed or unconfirmed. Within this implementation period confirmed/unconfirmed projects may switch to a revision status or switch to unconfirmed/confirmed status. In this first exercise we treat all this implementation period as one state. Just as the diverse symptoms a patient that just arrives at the hospital has during the course of the treatment. In this hospital example, the two terminal risks usually analyzed are the time of discharge from the hospital and the time of death.

Therefore, just like survival or duration analysis we can study the probabilities of duration until failure time but in this case, there are two competing causes that explains when a project ceases to be a project. The two workhorses in competing risk analysis are the cumulative incidence functions (CIFs) and competing risk regressions. These two objects resemble the estimation of survival functions and the Cox proportional hazard model in standard survival analysis.

The cause-specific cumulative incidence function (CIF), also known as sub-distribution function is defined for example in Lawless (2011). Let T be the project duration time until failure and let j be a cause of failure, the the CIF due to cause $J = j$ is

$$F_j(t) = Pr(T \leq t, J = j) = \int_0^t \lambda_j(u) S(u) du \tag{2}$$

where $S(t) = Pr(T \geq t) = \exp(-\Lambda(t))$, with $\Lambda(t) = \sum_j^2 \int_0^t \lambda_j(t)$. In this last expression $\lambda_j(t)$ are the cause-specific hazard ratio defined as

$$\lambda_j(t) = \lim_{\triangle t \to 0} \frac{Pr[t \le T < t + \triangle t, J = j \mid T \ge t]}{\triangle t} \tag{3}$$

This is an instant probability of failure due to cause j conditional the project is ongoing up to time t. The CIF represents the expected proportion of projects experiencing a certain competing event over the course of time. In other words, it is the probability of failure from cause j until time t in the presence of all other possible causes. It depends on the cause-specific hazards for all other causes.

To see the effects of covariates, we put attention to two objects; cause-specific hazard modeling or sub-distribution modeling. The proportional cause-specific hazard model with covariates takes the form

$$\lambda_j(t \mid x, \beta_j) = \lambda_0(t) \cdot g_j(x, \beta_j), \qquad j = 1, 2, \quad \beta_j \in \mathbb{R}^{p_j} \tag{4}$$

where $g_j : \mathbb{R}^p \times \mathbb{R}^{p_j} \mapsto [0, \infty]$, with $g_j(1, 0) = 0$ for all x

And the sub-distribution hazard modeling starts with the definition of the CIF for cause j given covariates x

$$F_j(t \mid x) = P(T \le t, J = j \mid x) \tag{5}$$

The analysis is done via the sub-distribution hazard function, so that

$$F_j(t \mid x) = 1 - \exp\left(- \int_0^t \lambda_j(s \mid x) ds \right) \tag{6}$$

Fine & Gracy (1999) assumes the Cox regression of the form

$$F_j(t \mid x) = 1 - \exp\left(-\Gamma_j(t) exp(x\beta_j) \right) \tag{7}$$

In sum, we are interested in estimating the shape of non-parametric CIFs as in equation 2 and sub-distribution hazard regression as in 7.

4 Results

4.1 Confirmed investment projects

We start by exploring the impact of commodity prices on the decisions of confirm/revise each investment project separately. For this analysis, we consider projects in different sectors of the economy, and separate it between mining projects, which are more closely linked to commodity prices, and other sectors of the economy, which might indirectly receive spillover effects.

Basically, we consider two variables that account for the effect of commodity prices on this decision, the variation and the volatility. When considering the mining sector, we consider the price of the mining product that would be extracted at that particular project. In other cases, we consider the terms of trade index. The results are shown in Table 2.

Table 2. *Marginal effects on the probability of unconfirmed projects in all sectors of the economy.*

Prob (confirmed)	Marginal effects					
	Mining		Other sector		All sectors	
Comm price growth	-0.0169	*	-0.0019		-0.0109	*
Comm price volatility	0.0407	*	0.0112	*	0.0482	*
Foreign ownership	-6.69e-06	*	-1.87e-06	*	-8.53e-06	*
Total financing (size)	0.0009	*	0.0003		0.0010	*
Conflict	-0.0066	*	-0.0005		-0.0032	*

*NOTE: * denotes that the coefficient is statistically significant at the 5 percent level.*

If we consider all sectors in our estimation, we find that higher commodity price volatility and a fall in commodity prices increase the probability of unconfirmed projects. The variable on volatility is associated with the higher uncertainty effect, where firms would be more willing to wait until periods of high volatility dissipate to gain more information and decide on their investment plans for the future. Other control factors include the total size of the investment project, where larger projects are more likely to be unconfirmed, and the foreign investors participation, which create less incentives to revise an investment project to unconfirmed.

When we separate the sample between investment projects in the mining sector and other sectors of the economy, as shown in Table 2, we observe that commodity price variations and volatility have larger impacts on the probability of being unconfirmed in the mining sector, as their profitability is more directly affected by commodity prices. For instance, the effect of commodity price variations is only statistically significant at the 5 percent level for the mining sector, as it has a direct impact on the profitability of these projects. A one percent increase in commodity prices reduces the probability of being unconfirmed by 1.69 percent.

On the other hand, volatility in commodity prices increases uncertainty and therefore leads to higher incentives to unconfirm or revise an investment project, especially in the case of projects that are still at the initial stage and has not required yet of a significant disbursement. For an additional 1 percent of commodity price volatility, the largest impact is observed in the mining sector, with an increase in probability of being unconfirmed by 4.1 percent compared to 1.1 percent for projects in other sectors of the economy.

4.2 Delayed investment projects

Another aspect of the investment decision, especially relevant in projects that take time to build, is whether it is implemented on time. Therefore, we present the results for the determinants of delays in investment projects by sector, where the results in Table 3 show different patterns between the mining sector and other sectors in the economy.

Commodity prices have a significant impact on the decision to delay an investment project, both in terms of variations and volatility. On one hand, an increase in commodity prices lead to a lower probability of delay, because the commodity price in the case of the mining sector directly affects the future profitability of the project. Higher commodity prices increase revenues when operations begin and minerals are exported, so there is an extra incentive for firms to speed up investment and benefit from a cycle of high commodity prices. In particular, an increase in commodity prices by 1 percent in the last 12 months reduces the probability of delay in the mining sector by 2.7 percent, compared to a non insignificant effect on other sectors of the economy.

On the other hand, the effect of higher uncertainty of commodity prices depends on whether prices are on an upward or downward trend. Related literature mentions two effects of uncertainty. First, higher uncertainty create incentives for investors to wait and obtain more information before making the decision to invest, as if they have a valuable call option that is lost once the irreversible investment decision is made. However, for investment projects that take time to build and funds must be committed up front, investors also have a put option on the flexibility of the time of completion, which create incentives to speed up investment.[5] Our results show that the second effect of increasing incentives to invest dominates, as there is a lower probability of delay when volatility increases. However, the first effect of desincentivising investment is relevant for periods where commodity prices are declining.

Quantitative results for variables related to commodity price volatility show that, in times of increasing commodity price (good news), an increase in volatility by 1 percent reduces the probability of a delay in the mining sector by 8.6 percent, whereas in times of bad news the reduction in the probability of delay falls to only 2.0 percent.

[5]See Bar-Ilan & Strange (1996). In that model the intuition is that the opportunity cost of delays increase with uncertainty because if good news take place, then the firm cannot benefit from it if it has not started the investment process.

However, for other sectors of the economy, we only find that the higher uncertainty effect of commodity price volatility increases the probability of delay.

Additional results from the control variables show that larger projects have lower probability of delay. This might be related to the fact that these projects usually involve large sums that are irreversible and can therefore be categorized as a sunk cost. Once part of the investment has already been disbursed, firms would be less likely to delay the beginning of operations as they would like to reap on the income from the mineral extraction as soon as possible.

Table 3. *Marginal effects: Probability of delay in investment projects in all sectors of the economy*

Variable	Marginal effects					
	Mining		Other sectors		All sectors	
Comm price growth	-0.0266	*	-0.0052		-0.0439	*
Comm price volatility	-0.0864	*	0.1362	*	0.0156	
Comm price volatility (downward)	0.0664	*	-0.0045		0.0154	
Foreign ownership	2.73e-06	*	7.70e-07		1.30e-06	*
Total financing (size)	-0.0003	*	0.0001		-0.0001	
Conflict	-0.0094	*	-0.0167	*	-0.0145	*

* *denotes that the coefficient is statistically significant at the 5 percent level.*

We also calculate the marginal effects by changing the variable related to social conflicts, by considering only the ones directly related to the mining sector, given that these are the ones that directly affect investment decisions in the sector. Once we control for this, we obtain similar results in terms of the effect of commodity price growth and volatility on the delay of mining investment projects, but now the higher the number of conflicts in the mining sector leads to a higher probability to delay. This is shown in Table 4.

We also run similar estimations for confirmed investment projects in other sectors of the economy where projects take time to build, and separate them by sector type: hydrocarbons, electricity and infrastructure, which are presented in Table 5. We find

Table 4. *Marginal effects: Probability of delay in investment projects in the mining sector*

Variable	Marginal effects Mining	
Comm price growth	-0.0138	**
Comm price volatility	-0.0469	**
Comm price volatility (downward)	0.0466	*
Foreign ownership	1.78e-06	**
Total financing (size)	-0.0002	**
Conflict	0.0032	*

*NOTE: * denotes that the coefficient is statistically significant at the 5 percent level, ** denotes that the coefficient is statistically significant at the 10 percent level.*

similar results regardless of the sector. In these cases, we observe that only the volatility of terms of trade is relevant whereas its growth rate is non significant. This result is expected given that the evolution of terms of trade is not directly linked to the profitability of investment, as in the case of the mining sector. At most, it could only be expected to have an indirect effect in the amount of resources available in other sectors of the economy, which creates income effects for agents whose activities are tightly linked to mining and that might spillover through an increase in their spending.

Table 5. *Marginal effects: Probability of delay in other sectors*

Variable	Marginal effects					
	Hydrocarbons		Electricity		Infrastructure	
Comm price growth	-0.0127		-0.0097		-0.0043	
Comm price volatility	0.1807	*	-0.0886		0.0362	*
Comm price volatility (downward)	-0.0127		-0.0023		-0.0004	
Foreign ownership	-0.00001	*	9.02e-06	*	3.06e-07	
Total financing (size)	0.0010	*	-0.0001		0.0001	*
Conflict	-0.0351	*	-0.0218	*	0.0106	*

*NOTE: * denotes that the coefficient is significant to 5 percent.*

By comparing the effect of uncertainty in commodity prices, we find that volatility in terms of trade increase the probability of delay the most in the hydrocarbons sector, related to the price of oil and therefore whose profitability if more closely related to commodity prices, whereas the smallest increase is observed in the electricity sector.

Now we focus our attention on mining projects only and analyze if there is a differentiated impact of commodity prices on the revised completion dates when an investment project is delayed, and whether more abrupt commodity price fluctuations lead to longer delay horizons[6]. For this, we constructed a dependent variable with the number of months between the revised expected and original dates of completion.

Table 6. *Determinants of announced delays of investment in the mining sector*

	(1)		(2)		(3)		(4)	
Comm price growth	-0.4688	*	-0.1102	**	0.0163		-0.0008	
Comm price volatility	0.7692	*	0.0227		-1.0252		-1.0262	*
Comm price volatility (downward)	—		1.3147	*	1.2381	*	1.3020	*
Foreign ownership	0.0396	*	0.0385	*	0.0284	*	0.0294	*
Total financing (size)	0.0015	*	0.0014		0.0009	*	0.0011	*
Conflict (total)	-0.0477		-0.0335		—		—	
Mining conflicts	—		—		0.0444	*	—	
Environmental conflicts	—		—		—		0.0144	*

*NOTE: * and ** denote that the coefficient is significant to 5 and 10 percent, respectively.*

Table 6 shows the results. A longer delay for the expected time of completion is expected following a reduction in commodity prices and an increase in commodity price volatility, consistent with the effects on the probability that an investment project is delayed. Therefore, the two results show that a period of falling commodity prices with sharp fluctuations not only increases the chance that the project takes more time to be implemented but it will start its operations in a much longer period of time.

Regarding other project specific determinants, we find that higher dependence on external funding and projects that involve larger disbursements of money are delayed for longer periods of time. Given the high initial fixed cost of operating in the mining sector, projects that are on the initial stages of implementation are more likely to wait until periods of high uncertainty dissipate and there is a more informed view of the project's profitability prospects.

[6]We also analyzed the delay period with respect to the original date of expected completion for projects in other sectors but did not find evidence of different timings in the delays.

Another exercise that we considered is the existence of a differentiated effect between small and large investment projects. For this, we separated the projects in tow groups according to the size of total financing. We established the threshold at the median of the distribution of projects in our database. We focused on the effect of commodity price growth and volatility of small and large investment projects. Table 7 shows the results.

Table 7. *Marginal effects: Probability of delay. Differentiated effects between large and small projects.*

	All sectors		Mining		Other	
Comm price growth	-0.0787	*	-0.0911	*	-0.0091	
Comm price growth (big projects)	0.0461	*	0.0806	*	0.0029	
Comm price volatility	0.0502	*	-0.0661	*	0.1467	*
Comm price volatility (big projects)	-0.0636	*	-0.0291		-0.0206	
Comm price volatility (downward)	-0.034	*	-0.0364	**	0.0131	
Comm price volatility (downward, big projects)	0.0718	*	0.1326	*	-0.0325	
Foreign ownership	1.26e-06		2.90e-06	*	6.90e-07	
Total financing (size)	-0.0001		-0.0003	*	0.0001	
Conflict	-0.0144	*	-0.0090	*	-0.0174	*

*NOTE: * and ** denote that the coefficient is significant to 5 and 10 percent, respectively.*

Results show the existence of differentiated effects for larger projects especially in the mining sector. The probability of a large mining project being delayed is less sensitive to commodity price fluctuations, where a one percent increase in commodity prices leads to a 0.09 percent lower probability of being delayed for small projects, but only to a 0.01 percent reduction for large projects. In the case of commodity price volatility in bad times, higher uncertainty only increases the probability of delay for large projects.

4.3 Competing risk regressions

In this part we track the project status in implementation as confirmed, unconfirmed or under revision and account for the time until either cancelation or completion time.

As Table 8 show, most of the observations are censored, which means that until the end of the sample, the projects have not failed (completed or canceled) yet. Another important feature of Table 8 is that almost all of the projects belong to the sector labeled “other” which comprises for example the construction of hotels, university campuses, shopping malls and the like.

	Sector	Censored	Canceled	Completed
1	Agro-industry	40	0	3
2	Electricity	73	2	26
3	Hydrocarbon	54	1	15
4	Industry	88	2	18
5	Infrastructure	56	3	18
6	Mining	86	3	18
7	Other	483	2	75
8	Fishing	10	0	4
9	Telecom	27	0	2

Table 8. *Number of projects according to status*

On the other hand, Table 9 shows the average time of project according to status. Projects in the infrastructure and mining sectors are the ones that maintain their status of implementation for more time, consequently at the end of the sample size of 82 months, these projects are censored. Also, we can notice that mining projects have been canceled earlier.

Cumulative incidence functions: With this type of competing risk data by sectors, we first estimate the CIFs by sector as shown in Figure 6. The figure shows that probabilities of both competing risks according to project age in each sector. In all cases, completion is more likely than cancelation. In general, the probability of project cancelation is low, below ten percent and only in mining and infrastructure they rich to about five percent. In the mining sector, the probability of cancelation smoothly increases as project age grows. In the infrastructure sector, cancelation probability only rises during the initial months.

Sectors	Censored	Canceled	Completed
Agro-industry	34.3		15.3
Electricity	36.3	16.0	38.1
Hydrocarbon	39.6	25.0	26.1
Industry	34.8	20.0	25.7
Infrastructure	43.7	7.0	25.9
Mining	45.4	38.3	26.1
Other	32.5	25.0	16.2
Fishing	35.2		16.3
Telecom	36.0		37.0

Table 9. *Average time of projects according to status*

Regarding completion probabilities, the mining sector probability only rises to about 25 percent at the end of the sample. In general all completion probabilities end up at about 30 percent except the electricity sector probabilities which end up in about 60 percent after 82 months of project implementation. This feature is the result of the huge amount of censoring in the data. It is not possible to know whether the shape of the CIFs bend upwards in the next five years after the sample or if they will keep their concave pattern.

Proportional sub-distribution hazard regressions: Now we perform the regression described in equation 7. The results are shown in tables A-1 through A-10 in appendix A. Given the small number of canceled observations, the results about cancelations may not be robust. However, the results about duration of project until completion are more meaningful.

In all regressions, we used three covariates for each project. First, a variable linked to commodity price variations since the inception of the project until failure time. In the case of censoring the change is from the project inception time to the final observation. In all cases we use the logarithmic change in the general export price index except for the mining sector where the change in margins is used. The second covariate used is the size of foreign investment associated to the project at the time

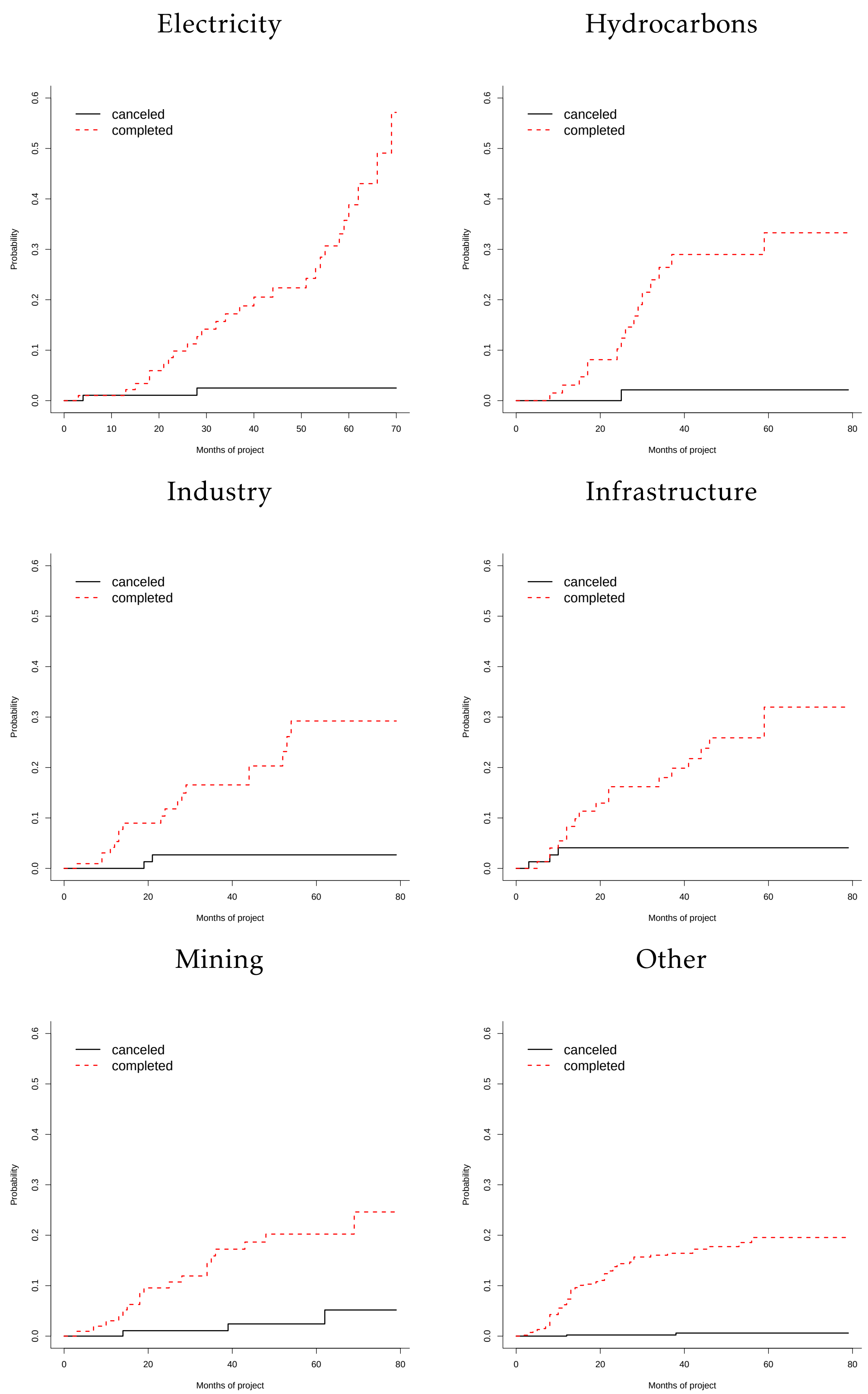


Figure 6. *Cumulative incidence function by sector*

of failure or censoring time. The third variable is the change in the environmental conflict ratio from inception to failure or censoring.

The key result is that an fall in export prices or a fall in margins reduce the probability of completion in all sectors of the economy. This results is compatible with previous results presented in the paper and highlight the important role of export prices to speed up projects, even if the particular investment project is not directly related to the commodity sector. The fall in the completion probability may be due to delays associated with the reduction of profitability as shown in the previous subsection.

Also, an important result is that a rise in the proportion of environmental conflicts reduce significantly the probabilities of completion in all sectors except electricity. A rise in environmental conflicts may be linked to a rise in total costs associated to the project that produces delays and hinders completion.

To further examine the effect of commodity prices on the two competing events in the mining sector, we graph the predicted CIF curves under a benchmark case compared to a counterfactual situation for the values of the covariates. In the benchmark case, the covariates for the mining sector are the average levels. In the base case, foreign direct investment associated to the project is USD 527 millions, margins have decreased in 26 percent and the conflictivity ratio has increased 21 percent. In the counterfactual case we keep all based values but the margins. Specifically, margins do not fall in the counterfactual case.

The results are shown in Figure 7. As observed, if margins had not fallen, the completion probabilities would have doubled towards the end of the fifth year from 20 to 40 percent. The same happens with the cancelation probabilities but the probabilities are so small that statistically they might be the same.

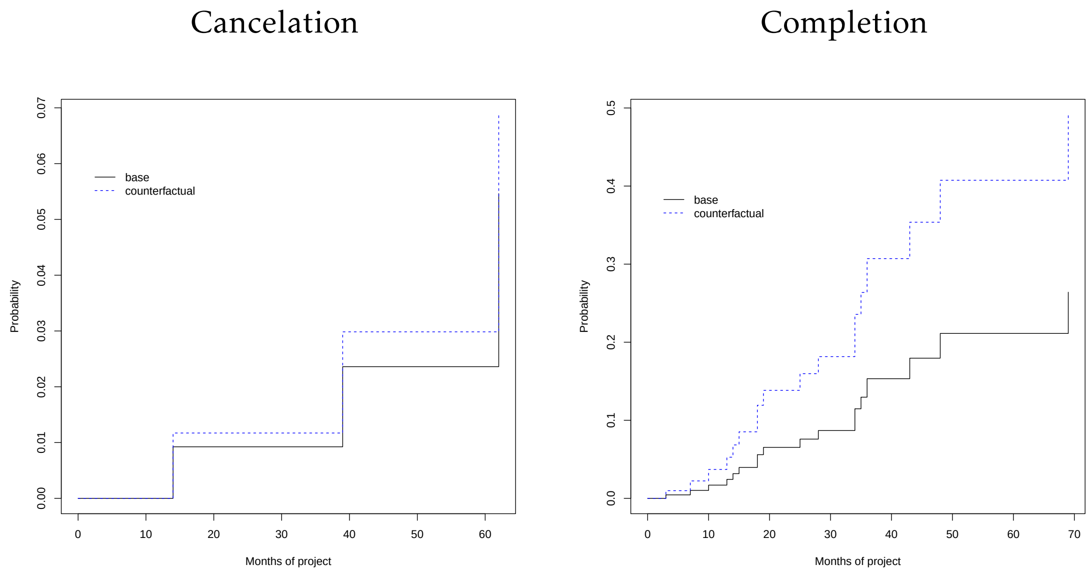


Figure 7. *Predicted CIFs under base and counterfactual case*

5 Conclusions

This paper uses a novel dataset of investment project states at the project levels across sectors in the Peruvian economy since 2009 to October 2015. A number of models are run to uncover basic features and relationships with covariates. In particular the paper is interested on the effect of commodity prices on investment projects in general and mining investments in particular.

Commodity prices are highly relevant for investment project decisions by firms, not only in sectors whose profitability is directly affected by them(ie mining sector in Peru), but also create spillover effects in other sectors of the economy as well. In the mining sector, the decision to revise an investment project is affected by both commodity price growth rates and volatility, where a reduction in commodity prices and lower commodity price volatility leads to a lower probability for a project to be unconfirmed. In contrast, other sectors of the economy are only affected by commodity price volatility, where higher uncertainty creates more incentives to unconfirm or revise an investment project.

Once an investment project implementation is ongoing, the probability that a firm chooses to delay its completion and start production is also affected by the evolution of commodity prices. For the mining sector, both commodity price growth rates and volatility matter, whereas the delay probability is only affected by volatility for other sectors. An increase in commodity prices reduce incentives to delay by affecting the expected profitability of the project. In the case of volatility, if taken as a measure of uncertainty, higher volatility leads to more incentives to postpone or delay investment. However, a second effect that is relevant in the case of the mining sector is that the possibility of better news than expected leads to higher incentives to start production and reap on the benefits of this in terms of higher profits.

Last but not lease, commodity prices do have a negative strong and statistically significant effect on the probability of project completion in all sectors. Particularly in the mining sector.

Future avenues of research point to considering the transmission mechanisms that generates the spillover effect to other sectors of the economy. Given that commodity price volatility generates higher uncertainty and incentives to delay or cancel an investment project, identifying the transmission channel would be key to target policy recommendations that could ameliorate the effect of commodity price shocks on aggregate investment and its implications on long term growth potential. One possible channel is through the existence of input output linkages between the mining sector and other sectors of the economy, as investment in new mining units would, for instance, require complementary investment in infrastructure and electricity.

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Appendix

A Tables

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.81	0.45	0.06	-12.5	0
Growth of export prices	0.67	1.95	0.03	25.0	0
Growth of conflict ratio	-8.15	0.00	0.46	-17.8	0
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	0.45	2.24	0.39	0.51	
Growth of export prices	1.95	0.51	1.85	2.06	
Growth of conflict ratio	0.00	3469.54	0.00	0.00	

Table A-1. *Electricity: Cancellation regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.00	0.10	0.00	-1.74	0.08
Growth of export prices	0.03	1.03	0.01	2.88	0.00
Growth of conflict ratio	-0.02	0.99	0.02	-0.93	0.35
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	1.00	1.00	1.00	1.00	
Growth of export prices	1.03	0.98	1.01	1.04	
Growth of conflict ratio	0.99	1.02	0.95	1.02	

Table A-2. *Electricity: Completion regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.00124	0.999	0.00106	-1.174	0.2400
Growth of export prices	-0.00778	0.992	0.04010	-0.194	0.8500
Growth of conflict ratio	-0.32661	0.721	0.10534	-3.101	0.0019
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	0.999	1.00	0.997	1.001	
Growth of export prices	0.992	1.01	0.917	1.073	
Growth of conflict ratio	0.721	1.39	0.587	0.887	

Table A-3. *Hydrocarbons: Cancelation regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.000565	0.999	0.000294	-1.92	0.05500
Growth of export prices	0.043446	1.044	0.011613	3.74	0.00018
Growth of conflict ratio	-0.096925	0.908	0.029413	-3.30	0.00098
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	0.999	1.001	0.999	1.000	
Growth of export prices	1.044	0.957	1.021	1.068	
Growth of conflict ratio	0.908	1.102	0.857	0.961	

Table A-4. *Hydrocarbons: Completion regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.000865	0.999	0.00173	-0.501	6.2e-01
Growth of export prices	0.036612	1.037	0.00887	4.126	3.7e-05
Growth of conflict ratio	-0.020403	0.980	0.04410	-0.463	6.4e-01
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	0.999	1.001	0.996	1.00	
Growth of export prices	1.037	0.964	1.019	1.06	
Growth of conflict ratio	0.980	1.021	0.899	1.07	

Table A-5. *Industry: Cancelation regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.000756	0.999	0.000884	-0.856	3.9e-01
Growth of export prices	0.030492	1.031	0.004457	6.842	7.8e-12
Growth of conflict ratio	-0.098769	0.906	0.033534	-2.945	3.2e-03
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	0.999	1.00	0.998	1.001	
Growth of export prices	1.031	0.97	1.022	1.040	
Growth of conflict ratio	0.906	1.10	0.848	0.967	

Table A-6. *Industry: Completion regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	0.000193	1.000	0.00185	0.104	0.92000
Growth of export prices	0.041986	1.043	0.01254	3.348	0.00081
Growth of conflict ratio	-0.081508	0.922	0.03061	-2.663	0.00770
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	1.000	1.000	0.997	1.004	
Growth of export prices	1.043	0.959	1.018	1.069	
Growth of conflict ratio	0.922	1.085	0.868	0.979	

Table A-7. *Infrastructure: Cancelation regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	0.000831	1.001	0.000637	1.30	1.9e-01
Growth of export prices	0.048407	1.050	0.008055	6.01	1.9e-09
Growth of conflict ratio	-0.056433	0.945	0.020004	-2.82	4.8e-03
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	1.001	0.999	1.000	1.002	
Growth of export prices	1.050	0.953	1.033	1.066	
Growth of conflict ratio	0.945	1.058	0.909	0.983	

Table A-8. *Infrastructure: Completion regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	-0.000441	1.000	0.000415	-1.062	0.29
Margin	0.009080	1.009	0.012809	0.709	0.48
Growth of conflict ratio	-0.039287	0.961	0.030111	-1.305	0.19
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	1.000	1.000	0.999	1.00	
Margin	1.009	0.991	0.984	1.03	
Growth of conflict ratio	0.961	1.040	0.906	1.02	

Table A-9. *Mining: Cancelation regression*

	coef	exp(coef)	se(coef)	z	p-value
Foreign finance	0.00	1.000	0.000312	0.139	8.9e-01
Margin	0.03	1.031	0.006678	4.522	6.1e-06
Growth of conflict ratio	-0.07	0.933	0.020699	-3.343	8.3e-04
	exp(coef)	exp(-coef)	2.5%	97.5%	
Foreign finance	1.000	1.00	0.999	1.001	
Margin	1.031	0.97	1.017	1.044	
Growth of conflict ratio	0.933	1.07	0.896	0.972	

Table A-10. *Mining: Completion regression*

B Graphs

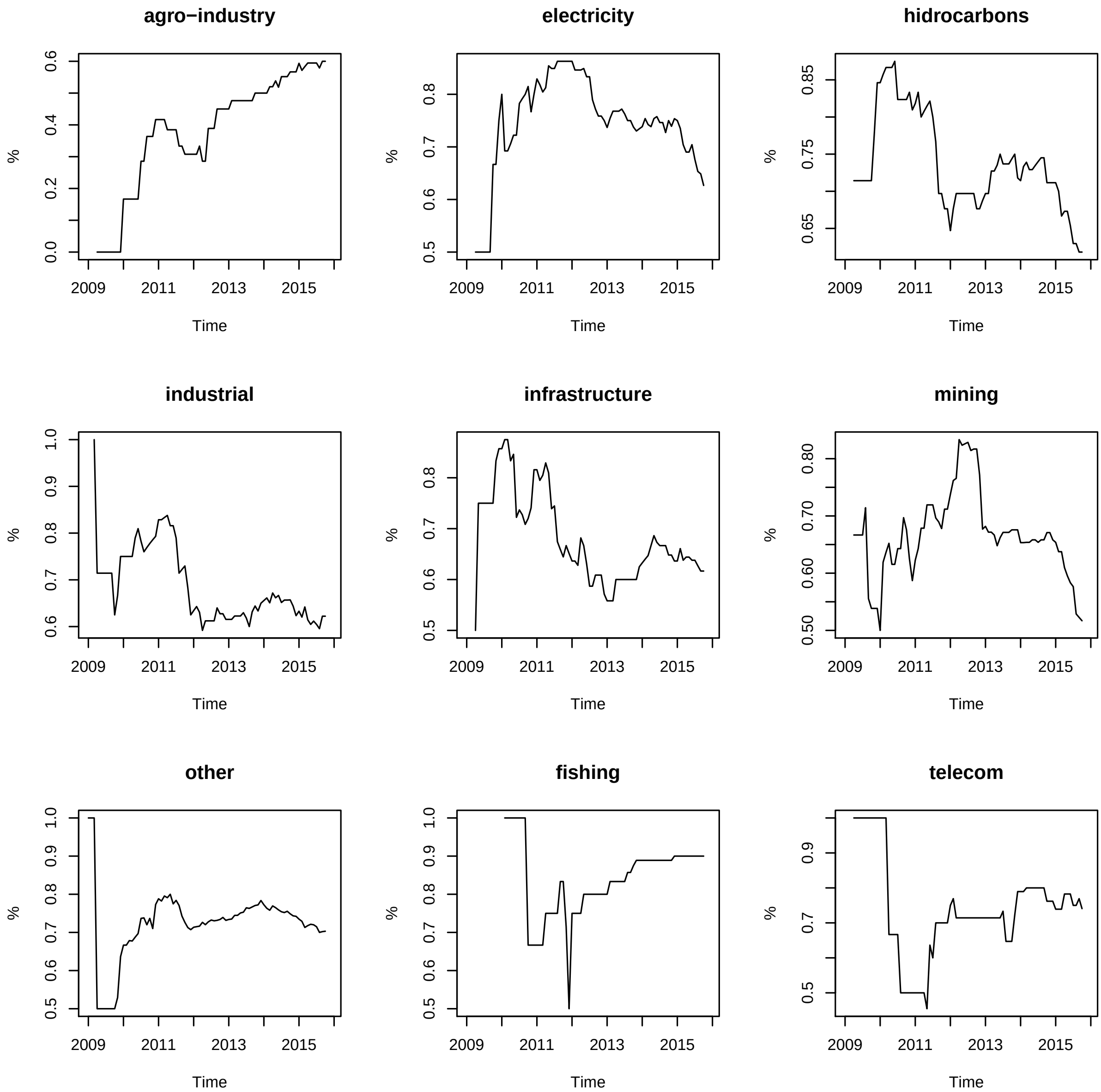

FIGURE B-1. *Proportion of confirmed projects to total projects in each sector*