Gold exploitation and socioeconomic outcomes: the Case of Burkina Faso

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August 29, 2016

Abstract

This paper investigates how the gold boom occurred since 2007 has affected socioeconomic outcomes in Burkina Faso. A reduced theoretical model was developed to show the expected impacts, and that were validated by the empirical analysis. Results suggest that areas hosting a gold extraction have better average living standards in terms of headcount ratios, poverty gaps and household expenditures than their counterparts without gold. However, this can increase inequality and child labor. It therefore raises the growing need of the governmental interventions to reverse such negative impacts.

Keywords: Gold mining, Poverty, Inequality, schooling, child labor, Burkina Faso.
JEL Codes: D11; I32; O13; Q33.

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Executive summary

Burkina Faso is considered as a low-income country. The principal economic activity is agriculture, and the majority of the people are poor. For instance, almost half of the population is still below the poverty line in 2009. In the same year, the agricultural sector (including forestry, hunting, fishing, crops and livestock production) represented about 35% of the GDP and 85% of the working population (see statistics from the African Economic Outlook). Burkina Faso also has mining resources. The mining sector (mainly consisting of gold production) plays an increasingly important role in the economy of Burkina Faso. Before 2007, the gold mining sector was dominated by artisanal and small-scale gold mining, and the contribution of the sector to the national revenue was not substantial. However, since 2007 the government has initiated many reforms to increase revenue from gold production, and to reduce poverty. The consequence of these reforms is the gold mining boom experienced over the period 2007-09.

From 2007 to 2010, seven gold mining companies came into operation and gold production has been multiplied by thirtyfold. In 2010, the revenue from gold exploitation represented 67% of total revenues from exportation and 9.8% of GDP. Moreover, in 2012, the earnings from the exploitation of gold substantially raised from 437 billion CFA francs to 806 billion CFA francs. Based on this performance of the country in terms of gold production, some questions may arise. Does this gold boom impact the living standards in Burkina Faso, particularly the poverty rates and the inequality? What is the effect of this resource boom on schooling and child labor? Our main objective in this study is to answer these questions.

In the literature, the effect of natural resource exploitation on economic performance is diversely discussed. A trend of that literature described a negative impact of natural resources while the other considered that natural resource exploitation should not harm economy. The mainstream message is that the result depends on the indicator used to assess economic performance, the economic policy, and the institutional environment under which the economy is led. The findings may significantly vary if we consider average income, schooling, poverty and inequality, investment, infrastructure creation, or social stability. Most of the studies have found that natural resource boom is a source of income increase. But this increase in income is generally challenged by lower

schooling or inequalities exacerbation.

In this paper, we investigate the effects of gold exploitation on poverty, inequality, average income, schooling and child labor. First, we develop a theoretical model to show the effects of gold exploitation on expenditure, inequality and schooling. Second, we estimate the effects using household data.

Based on this model, we find that gold exploitation has positive effect on expenditure for both industrial and artisanal mining, and there is more inequality in industrial mining than in artisanal mining. We also find that gold exploitation increases school dropouts.

To estimate the effects empirically, we use microdata from household surveys (*Enquête Burkinabè sur les conditions de vies des ménages*, EBCVM 2003, and *Enquête intégrale sur les conditions de vies des ménages*, EICVM 2009) as well as administrative data. The 2003 survey covers a period where the formal gold extraction was in its infancy and the 2009 survey spans the period of the gold resource boom. The use of the two data sets enable an assessment of the extent to which the gold boom has contributed to improving living standards. Our method consists of comparing the outcomes of two groups. The first group named *producing departments* is composed of departments (or municipalities) in which there is gold extraction and the second group, the *non-producing departments* are those without gold extraction.

Our empirical findings show that gold exploitation may help reducing poverty and increasing average income. This suggests that a policy supporting gold extraction could lead to better average living standards in Burkina Faso. Although the effects on inequality, schooling and child labor are not clearly proved, there are good reasons to believe that gold exploitation may increase inequality in Burkina Faso. It may also have a negative effect on schooling and may have scaled up child labor in gold mining sites. Therefore, a policy supporting gold extraction should be paired with programs or strategies to prevent negative outcomes such as worsening inequality, school dropouts and child labor.

1 Introduction

1.1 Context of the study

Burkina Faso is a landlocked country and one of the poorest countries in the world. According to the 2015 Human Development Index report, Burkina Faso is ranked 183rd out of 188 countries. Poverty is still pervasive in the country. Indeed, it is estimated that 51% of Burkinabè were poor in 2003 and 47% in 2009 (World Bank 2013). The majority of people depend on agricultural activities and more than 75% of the population are still living in rural areas. Agriculture is a core sector of the economy and the authorities attempted to increase productivity in this sector by improving the irrigation of land. However, only 10% of land was reached by these irrigation initiatives. As a result, the country is struggling to find other way or resources for its economic development.

Burkina Faso is endowed with natural resources including gold. Since 1960, small-scale and artisanal gold mining has been developed. To date, however, the revenues from artisanal mining appear insufficient to initiate sustainable economic development. Because of this, in 2007, the country implemented three projects and launched many reforms intended to increase gold revenue and so to lead to poverty reduction. These projects aim to improve the cadastral plan and the financial management of mining activities, to strengthen small-scale mining, to regulate artisanal mining and to create a statistical database for monitoring the effects of mining on the environment (MME 2013). The major reform is the revision of the 2003 Mining Code to attract foreign direct investments in gold mining sector.

As a result, four commercial mining licenses and sixty nine exploration rights have been given in 2007. While no large-scale mining industry existed in 2003, there were five industrial mines in 2008. This has led to the gold mining boom observed since 2007, making gold the main product of exports and the main source of economic growth. At the end of 2015, eight industrial mines have been producing gold which include Taparko, Youga, Mana, Seguenega, Inata, Essakane, Belahouro and Bissa-Zandkom. The State is the main beneficiary of gold mining. The revenues from gold are entirely going its coffers. Since 2010, the government transfers 20% of the mining

land taxes levied on mining companies to departments and regions that host a mining activity. Producing departments receive 90% of the amount and the related regions receive 10%.

Although, gold exploitation has certainly contributed to boost the economy the last five years, it also has negative impacts. Adults as well as children are migrating periodically towards mining areas. One consequence of those internal migrations is the social conflicts between migrants and local people (Cote 2013a). Another consequence is child labor. Many primary school students as young as six are abandoning schools for artisanal mining sites. Whether industrial or artisanal, gold mining negatively affects environment and can potentially have health-related problems for the populations close to mining sites. The often listed concerns are the deforestation, the degradation of soil and the pollution of soil and water.

The necessity to contribute to local development and to increase the social benefit from gold exploitation has resulted in new amendments in the mining code in 2015 that oblige companies to increase local employment and business opportunities for Burkinabè. Companies are also compelled to contribute to building social infrastructures such as roads, schools and health facilities for local populations. In order to fight against child labor in artisanal mining sites, the 2015 Mining Code includes articles that provides for penalties for child labor law violations.

1.2 Research questions and objective

The so-called *resource curse* refers to a situation in which abundant natural resources do not help raise living standards of populations. This is a much-researched topic in the economics literature. Most studies have focused on the relationship between the abundance of natural resources and income inequality or income growth in a macroeconomic framework (see for example Leamer, Maul, Rodriguez, and Scott (1999), Fum and Hodler 2010 and Papyrakis and Gerlagh 2007). Mineral resource abundance as well as exploitation of natural resources has been found to have a negative correlation with long-term economic growth. Other studies based on a cross-country analysis report some more nuanced results (see for example Parcero and Papyrakis 2014).

In the case of microdata, the literature has focused on the links between natural resource extraction and poverty and inequality. The main findings suggest that industrial mining is likely

to be more associated with poverty exacerbation while artisanal and small-scale mining has a positive effect on poverty reduction. According to Gamu, Le Billon, and Spiegel (2015), this is due to the fact that industrial mining generate fewer employment opportunities than artisanal and small-scale mining. The existence of various empirical studies provides some insights on the relationship between extractive mining and poverty. However, little evidence is focused on low income countries and particularly Burkina Faso which experienced a gold boom since 2007.

Does this gold boom impact the living standards in Burkina Faso? The main objective of this research is to investigate how the gold boom has affected socioeconomic outcomes including poverty, inequality and expenditure. This is important for policy makers to improve the living standards of the population. Furthermore, this research examines the impact of the gold boom on schooling and child labor which were little-discussed in investigations of the resource curse.

Empirically, we find that areas hosting a gold extraction have better average living standards in terms of poverty rates and household expenditures than their counterparts without gold exploitation. Although the effects are not statistically significant on inequality, it is robustly positive. We also propose a theoretical model to assess the effect of gold exploitation on some outcome variables. Results are generally consistent with the empirical findings.

The rest of the paper is organized as follows. Section 2 presents a brief literature on natural resources. Section 3 describes the situation of gold exploitation in Burkina Faso. In Section 4, we develop a theoretical model followed by an empirical strategy to assess the effects of gold exploitation on the outcomes. We also describes the data. Section 5 presents the findings and Section 6 concludes.

2 Literature review

The link between natural resources and economic performance is extensively discussed in the literature. While one trend of that literature has described a negative impact of natural resources, mainly under the hypothesis of Dutch disease (Sachs and Warner 2001, Davis and Tilton 2005, Mogotsi 2002, Corden and Neary 1982, Karl 2004) or under the more general concept of resource

curse (Collier and Hoeffler 2000, Ross (2004), Leite and Weidmann (1999)), the other has argued that natural resource exploitation should not harm economy (Petermann, Guzman, and Tilton 2007, Davis 1995, Stijns 2005, Torvik 2001, Gylfason 2001). In general, the result depends on the indicator used to assess economic performance, economic policy, and the institutional environment under which the economy is led. The findings may significantly vary if we consider average income, schooling, child labor, poverty and inequality, investment, infrastructure creation, or social stability as economic performance indicators.[1] Most of the studies have found that natural resource booms are a source of income increases. But the rest of effects is generally undermined by lower schooling and an increase in child labor. For instance, Santos (2014) shows that gold boom increases child labor and decreases school attendance in Colombia. In the same vein, Kruger (2007) finds that a coffee boom led to higher child labor and school dropouts particularly for poor households in rural Brazil.

Goderis and Malone (2011) used a theoretical and empirical analysis to examine the effect of resource exploitation booms on income inequality. In the theoretical model, they consider two types of labor (skilled and unskilled) and two production sectors (traded and non-traded) with a CES utility function. Theoretically, the paper finds that resource exploitation should reduce income inequality in the short term if the non-traded sector is intensive in unskilled labor. This finding is confirmed by empirical analysis. Howie and Atakhanova (2014) apply Goderis and Malone (2011)'s theoretical findings to assess empirically the effect of resource exploitation boom on income inequality. The paper finds that resource booms decrease inequality, and that institutional quality and public health programs play an important role in that reduction. Using district-level data from Peru, Loayza, Alfredo, and Rigolini (2013) find that mining activity leads to an increase in household consumption, and a decrease in poverty and illiteracy rates. However, this positive effect is mitigated by an increase in consumption inequality. In the same country, Aragon and Rud (2013) observed that gold exploitation increases local real income even though this is comes along with an increase in the local price of non-tradable goods. Fisher, Mwaipopo, Mutagwaba, Nyange, and Yaron (2009) examined artisanal mining (specifically gold and diamonds) in Tan-

[1]For a more complete survey on the literature about natural resources and the economy, see van der Ploeg (2011).

zania. They show that the sector contributes to poverty reduction inside the population of mine workers. However, because of the non-regularity of the mining activity, it may lead to insecure standard of living. The effect of artisanal mining may be altered by the formal (industrial) mining. This is the case in Burkina Faso where the positive impact of artisanal mining on poverty reductions is enhanced by the effect of formal mining on infrastructure creation. This is shown in an IMF country report of July 2014 (IMF 2014). Fum and Hodler (2010) introduced ethnical aspect in the analysis. The result is that natural resources exploitation leads to civil conflicts and ends up with increase in income inequality if the population is ethnically polarized. However, if the population is ethnically homogeneous, natural resources reduce income inequality. With cross-sectional data on different countries around the world, Leamer, Maul, Rodriguez, and Scott (1999) concluded that the use of natural resources delays industrialization and reduces the size of high-educated population because workers are attracted by the natural resources sector which does not require qualified labor. Pegg (2010) seems to find an opposite result in Botswana where diamond has a positive effect on education (size of educated population), savings and infrastructure creation, even if the country is still struggling to diversify its economy.[2] Ge and Lei (2013) used a multiplier decomposition method and the social accounting matrix of China and showed that, in terms of income increase and poverty reduction, mining activity contributes significantly to economic performance. However, this positive impact is more beneficial to the high and middle income class than the low income households. Buccellato and Mickiewicz (2009) stressed the effect of corruption on natural resource benefit. In their paper the authors considered the case of oil and gas in Russia and mentioned that natural resources lead to higher average incomes. However, because of corruption and weak economic institutions, this increase in income goes hand-in-hand with larger inequality. Papyrakis and Gerlagh (2007) use disaggregated state-level data for the US. They find that resources abundance has negative impacts on investment, schooling and openness. However, in the presence of good institutions, efficient economic policies and planning, resources exploitation may still be beneficial. In developing countries, artisanal mining may lead to some

[2] See Karl (2004) who mentioned a similar result with oil exploitation. Indeed, the earlier stages of oil boom are characterized by an increase in per capita income, employment rate, and infrastructure creation. But after a while, this good economic performance is mitigated by the incapacity of the country to diversify its economy.

gender-based social problems. Indeed, on the mining sites girls and young women are exposed to sexual harassment, violence, exploitation, infectious diseases, etc., (Werthmann 2009).

3 Gold exploitation in Burkina Faso

Burkina Faso has been producing and exporting gold since 1960. Gold mining became a major sector in the country during 2007-09 given the quantity produced and the revenue it generated when world gold prices rose substantially. During the 1980s, the "Bureau des Mines et de la Geologie du Burkina" (BUMIGEB), with the support from the World Bank, identified several potential gold mine sites. As of 1991, the country had a mining policy. Liberalization of the mining sector began with the adoption of the Mining Code in 1997. This code was revised in 2003 and 2010. A new Mining Code was adopted in June 2015. Since 1995, the country has engaged in an aggressive mining promotion policy with the organization of annual days of Mines (PROMIN). The combination of all these factors explains the mining boom observed since 2007.

Between 2007 and 2010, seven gold mining companies came into operation. Gold production multiplied by thirtyfold between 2007 and 2010. The country rose to the rank of third gold producer in the West Africa region as of 2015. Burkina Faso is the African country where the increase in gold exploration expenditures has been the most important in recent years. Ranked 8th in 2009, Burkina Faso became the first African country in 2011 in terms of spending on gold exploration. Indeed in 2012, there were more than 80 gold deposit exploration projects, among a total of 250 in all Sub-Saharan Africa.[3] The boom in the gold mining sector also coincides with the increase in gold prices on the international market. Those prices increased by over 450% between 2003 and 2011, reaching $1,895 per once during 2014.

Over the period before 2007, the quantity of gold produced in Burkina Faso remained low and never exceeded 2 tons.[4] From 0.7 ton in 2007, the production jumped to 5.4 tons in 2008, more than seven times the 2007 production. In 2009, gold production was 12.1 tons. This represents an annual increase of more than 100%, and thereby brought Burkina Faso into the top five African

[3] See for instance KPMG (2013).

[4] See Conseil Économique et Social (2012).

countries gold producers. In 2014, the country is the fourth largest gold producer in Africa (after South Africa, Ghana and Mali) with approximately 36.1 tons of gold extracted and has a great potential to increase its output.

Despite the fact that the opportunities for direct employment in gold mining industry may be limited due to high-skill labor and the capital intensive nature of gold mining, the increase in the production of industrial mining has led to a significant increase of labor supply within the mining sector. Between 2008 and 2009, the number of permanent jobs created by gold mining companies has grown nearly twofold, from 1,725 people to 3,317 people. This number reached 5,535 people in 2012 of which 3,698 are Burkina Faso nationals.[5]

The main concern remains the huge gap between the wages of nationals and non-nationals due to the difference in skills and qualifications. For example, in the Kalsaka gold mining, the payroll for 345 national workers is estimated at 80 million CFA francs per month whereas it is 68 million CFA francs for 21 expatriates. Nonetheless, industrial companies contribute to job creation through indirect and induced jobs generated by suppliers to mining operations (See for instance, IFC 2009 and World Gold Council 2015).

It is also well-known that artisanal and small-scale mining generate more jobs than large-scale mining (see for instance Gamu, Le Billon, and Spiegel 2015). In the case of Burkina Faso, the increase in the number of people working in artisanal and small-scale gold mines is driven by the presence of significant gold deposits and gold discovery. Artisanal and small-scale mining sector accounts for more than 1 million people exploiting gold (Conseil Économique et Social 2012). Significant gold reserves also have led to the emergence of large-scale industrial companies in Burkina Faso.

Besides, gold exploitation can positively affects the population wellbeing through social direct investments from companies. In Burkina Faso, those investments have helped improve access to some basic and social infrastructure and services particularly in some mining areas. Although they are not judged sufficient, they include schools, health centers, water, roads and electricity (Chambre des Mines du Burkina 2013 and Ouedraogo 2011).[6] However, gold exploitation could also

[5]These data are obtained from the Ministry of Mines and Energy.

[6]When completing the paper, we learn that the Government commissioned the Parliament to investigate a bit

affect the population wellbeing negatively. For instance, it may lead to environmental degradation and pollution of water.

Gold mining revenues are substantial. For example, in 2012, the production of gold contributed to 806 billion CFA francs in earnings from exportation whereas it was 437 billion CFA francs in 2010. This last amount represents 67% of export value and 9.8% of GDP. The contribution of mining companies to the government budget was 127 billion CFA francs in 2011 and 46.5 billion CFA francs in 2010. With the falling prices on the international market, the contributions of gold to the government budget fell from 191 billion CFA francs in 2013 to 168 billion francs CFA in 2014, representing a 12% reduction.[7]

Small-scale mining operations that are often unregistered (and sometimes illegal) have accounted for a significant amount of gold production in Africa before the advent of reforms which increased the presence of large multinational companies (World Bank 1992). In Burkina Faso between 1986 and 1997, small-scale artisanal mining production was 12 tons while the production from large-scale mines was 14 tons. But currently, in spite of the number of miners involved in artisanal production, the production is no longer significant. Indeed, in 2012, artisanal gold production accounted for only 3% of the total production. Many small businesses are operating without a license and with rudimentary equipment (ITIE-BF 2014). Child labor is particularly prevalent in artisanal production, and this has potentially negative implications for children's schooling. Besides, the other adverse effects of artisanal extraction are environmental degradation, health-related challenges and conflicts.[8]

Despite the gold boom in Burkina Faso since 2007, the contribution of the sector to poverty reduction could be judged to be low than expected. This suggests that the management and redistribution of the resources from gold exploitation in Burkina Faso remains a problem. For the social benefit from gold exploitation, the new Mining Code adopted in June 2015 provides: 1. The introduction of royalties on the extracted value (ad valorem) 1% that will lead to the development

more the social responsibility of mining companies.

[7]http://www.burkina-emine.com/?p=3168&lang=fr visited on October 3rd, 2015.

[8]See for instance Cote (2013b). Given the lack of information, we are unable to take into account these variables in our estimations.

of local communities; 2. A corporate income tax; and 3. A tax on income from securities which increases to 6.3%. As well, a local development fund is established for the improvement of local communities and the fight against environmental degradation. This is given by Articles 26-28 of the new Mining Code of 2015.[9]

4 Methodology

Our methodology is based on two main components. First, we develop a theoretical model to assess the impact of gold exploitation on a set of socioeconomic outcomes. Second, we follow an empirical strategy to estimate this impact using microdata from Burkina Faso.

4.1 Theoretical Model

The starting point is by modeling the representative household utility inspired from (Soares, Krueger, and Berthelon 2012). In this model, we consider a representative household of the department i. We also assume that the household has one adult and one child and its utility function is given by

$$u_i(c_i, h_i) = \alpha_i \ln c_i + \beta \ln h_i, \quad \text{with } \alpha_i > 0 \text{ and } \beta > 0. \tag{1}$$

where c_i is the household's consumption and h_i is the human capital of the child. We assume that α_i is a random variable with mean $\bar{\alpha}$. One unit of consumption is diversely valued over the households' population. For simplicity we abandon the subscript i. The human capital is produced according to the technology

$$h = A e_c^{\gamma} y^{1-\gamma}, \quad \text{with } 0 < \gamma < 1, \tag{2}$$

where e_c is the time devoted by the child to schooling (time spent in school), and y is the adult's investment in the child's human capital. Actually, y represents the material costs borne by the

[9] For more details, see Conseil National de la Transition (2015).

household, and that are required to produce the child's human capital (equipment, tuition fees, etc.). Let us consider the following notations: l_c is the child's labor supply, i.e., the time spent by the child in mining activity, t_c is the total amount of time available for the child, l_a is the adult's labor supply in mining activity, l_x is his labor supply in other activities than mining, t_a is the total amount of time available for the adult, $w_c > 0$ is the child's wage in mining activity. As we can observe in Burkina Faso, we distinguish two types of gold mining activity: artisanal mining and industrial mining. $w_i > 0$ and w_a are the wages the adult respectively in the industrial and the artisanal mining activities, and $w_x > 0$ is the adult's wage in the other activities. We assume that $w_a \leq w_x \leq w_i$. We have

$$t_c = e_c + l_c \quad \text{and} \quad t_a = l_a + l_x \tag{3}$$

We denote by $\mathbf{1}_D$ the indicator variable taking a value of 1 if the department where the household is living is a gold producing department. $\mathbf{1}_{D_I}$ is the indicator variable taking a value of 1 if there is an industrial production in the department where the household is living. We also assume that the price p of the commodity y is affected by the status of the department (producing or not producing), i.e.,

$$p = p_1 \mathbf{1}_D + p_0 \left(1 - \mathbf{1}_D\right), \tag{4}$$

where p_1 and p_0 refer to the price of the commodity y respectively in producing department and non-producing department. Two facts may lead to change in education goods prices. First, gold mining can induce population concentration in gold producing areas. This will increase demand for goods and then will increase prices. In such a situation p_1 is greater than p_0. In other words, gold boom leads to higher inflation. Second, gold exploitation may give the local authorities the financial capacity to subsidize education good, and p_1 will be lower than p_0.[10] A summary of our setup is as follows.

Utility function: $u(c, h) = \alpha \ln c + \beta \ln A + \beta\gamma \ln e_c + \beta(1 - \gamma) \ln y$.

[10] We may also assume that the price of consumption goods varies from a producing to a non producing department.

The household is subject to the following budget constraint:

Budget constraint: $c+py+w_c\mathbf{1}_D e_c \leq w_c\mathbf{1}_D t_c+\left(\left(w_i\mathbf{1}_{D_I}+w_a\left(1-\mathbf{1}_{D_I}\right)\right)\mathbf{1}_D-w_x\right)l_a+w_x t_a$.

We normalize the price of the consumption good to one.

The problem of the household is

$$\max_{c,l_c,l_a,y}\{\alpha\ln c+\beta\ln A+\beta\gamma\ln e_c+\beta(1-\gamma)\ln y\}$$

$$s.t\quad c+py+w_c\mathbf{1}_D e_c \leq w_c\mathbf{1}_D t_c+\left(\left(w_i\mathbf{1}_{D_I}+w_a\left(1-\mathbf{1}_{D_I}\right)\right)\mathbf{1}_D-w_x\right)l_a+w_x t_a \tag{5}$$

$$e_c \leq t_c \tag{6}$$

To solve the problem we consider three different cases: case 1 where $\mathbf{1}_D=0$, case 2 where $\mathbf{1}_D=1$ and $\mathbf{1}_{D_I}=1$, and case 3 where $\mathbf{1}_D=1$ and $\mathbf{1}_{D_I}=0$. For any variable Y we denote by Y_0, $Y_{1.1}$, and $Y_{1.0}$ its values respectively in case 1, case 2 and case 3. The results are presented in Table 1, where $\theta\equiv\frac{\beta\gamma}{\alpha+\beta-\beta\gamma}$.[11]

Examining Table 1 we can see that (for given value of parameters) the outcomes depend on wages distribution across departments. Specifically, all the outcomes are non decreasing functions of wages, except child schooling which is decreasing in child wage. Indeed, salary increase provides more revenue to households to consume more and be able to send children to school. In contrast, child wage is the cost of schooling. So, if the salary paid to children increases they will prefer gold activity to staying in school.

Another result from the model is that, even if schooling decreases with child wage it never gets to zero. Whatever the context, children will go to school. This is due to the importance of education in the utility function (Cobb-Douglas) of the households.

As we mentioned before, the goal of this section is to use a model to predict the effect of gold exploitation (industrial and artisanal) on some variables of interest. Specifically, in the next subsection, we discuss the effect of gold mining on child schooling (e_c), school good expenditure (y), consumption (c), and inequality in the total expenditure (consumption and school good) across households.

[11] Please see calculation details in Appendix A.

4.2 Expected effects of gold exploitation

To study the theoretical effect of gold exploitation, we calculate for each variable of interest Y the difference between case 1 and the other scenarios (case 2 and case 3). Specifically, we compute $Y_{1.1} - Y_0$, $Y_{1.0} - Y_0$, and $Y_{1.1} - Y_{1.0}$ (to compare artisanal and industrial mining). For example, to find the effect of gold exploitation on consumption we compute $c_{1.1} - c_0$, $c_{1.0} - c_0$, and $c_{1.1} - c_{1.0}$. We also compare the industrial exploitation to the artisanal one by computing $Y_{1.1} - Y_{1.0}$ for each variable of interest. Details of calculations are in Appendix B.

Gold mining effect on child schooling time

Theoretically, children stay less in school when there is gold exploitation. In other words, gold exploitation increases the school rate absenteeism as students use a part of their time in working in mining activity. Compared with the department with artisanal exploitation, children spend more time at school in the department with industrial exploitation. This result is due to our assumption that salaries of adults are higher in industrial mining than in artisanal mining. Therefore, because the adults get higher income, they do not need to ask children to work. They are more able to satisfy the household's needs. However, if the child wage is too low (in comparison with the other wages) then we observe the same schooling time in gold producing departments as in the non producing one. Figures 1 and 4 give an illustration of all these results.

Gold mining effect on school goods

The effect of gold exploitation on adults' investment in child human capital is ambiguous. The result depends mainly on p_0 (price of schooling goods in the non producing departments) and p_1 (price of schooling goods in the producing departments). If because of population concentration, gold mining results in an increase in schooling goods prices then parents will invest less in human capital. However, with gold mining, local government could subsidize education and decrease the prices of schooling commodities. In such a case, investments in human capital will increase. Figures 5 and 6 give an illustration of all these results.

Gold mining effect on households consumption

Theoretically, we find that gold exploitation has positive effect on consumption. This holds for both industrial and artisanal mining. However, industrial mining increases consumption more than artisanal exploitation does. Indeed, we assume that wage for adult is higher in industrial mining than in artisanal mining. Therefore, higher income allows the households to purchase consumption goods.[12]

Gold mining effect on inequality in households' expenditure

Although gold exploitation is source of increase in consumption and school good it may aggravate inequality in terms of total households' expenditure. The total expenditure of a household is the total amount spent by that household in consumption and in school good purchase. Both artisanal and industrial mining may be source of inequality aggravation. The result depends on the wages distribution as illustrated in Figure 2. Specifically, it depends on the child relative wage in mining (in comparison with the industrial mining wage and the wage in the other activity). Indeed, if the child wage is too low ($w_c \leq \theta \frac{t_a}{t_c} w_x$), gold exploitation is not source of inequality. If child wage is fair ($\theta \frac{t_a}{t_c} w_x \leq w_c \leq \theta \frac{t_a}{t_c} w_i$), artisanal mining is source of inequality. Finally, if child wage is too high ($w_c \geq \theta \frac{t_a}{t_c} w_i$) both artisanal and industrial mining are source of inequality aggravation, but industrial mining aggravates more inequality that artisanal mining. We come to this result for a simple reason. In our framework, the adult works full-time in any household, regardless of whether or not the department is a producing department. Therefore, what makes difference between households is the child work. Thus, if child wage is too low, the situation is close to that of no gold production because no child will work. If child wage is fair, the situation is equivalent to artisanal mining situation, because no child will work if mining is industrial. Child wage is not high enough to compensate for drop in utility due to less schooling. In case of high child wage, children will work and income is high and results in inequality. On the other hand, the effect of child wage is also conveyed through schooling and then human capital, not only from income increase. Indeed, child wage is the price of a good (schooling) which is directly used in the

[12] Here, we consider that the price of the consumption good is the same regardless of whether or not the household is living in a producing department. We could suppose a change in price due to gold exploitation, and the result will be ambiguous as we find for the school good.

utility function through the production of education good. In other words, child wage is the cost of human capital production. w_c has an impact on the effect on inequality because of education. If human capital has no effect on inequality then inequality will not depend on w_c. So, inequality aggravation solely depends on w_c because, in our model, there is human capital accumulation only for children, not for adults who work full-time.

Even if gold exploitation has clear effect on some outcomes, its effect on welfare is ambiguous as the effect on human capital is ambiguous. Mining allows people to have access to today consumption goods, but does not necessarily ensure human capital accumulation for the future generations.

4.3 Data

We gather data from different sources, microdata from household surveys and administrative data. The combining of different data sources is relevant for two reasons. First, in order to assess the effect of gold exploitation on income disparities, the use of microdata appears to be more appropriate. We rely on two nationally representative household surveys (*Enquête Burkinabè sur les conditions de vie des ménages*, EBCVM 2003, and *Enquête intégrale sur les conditions vie des ménages*, EICVM 2009). Second, while the 2003 survey covers a period where the formal gold extraction was in its infancy, the 2009 survey spans the period after a remarkable gold resource boom. This will enable an assessment of the extent to which the development of gold mining has contributed to improving local living standards.

Both surveys contain information on socio-economic characteristics, assets and consumption on around 8,500 households. The two samples cover all the regions and provinces of the country. In fact, Burkina Faso is divided into 13 administrative regions and 45 provinces. Each region is composed of 3 provinces and each province has 7 departments on average. The department is the smallest administrative area recorded in the data. The information related to gold extraction is also available at the department level. We therefore consider the unit of analysis to be the department. The 2009 sample contains 284 departments while that of the 2003 contains 234 departments. However, we rely on the departments that are common for both surveys, comprising

201 departments. We construct a balanced panel dataset of these 201 departments for the two periods 2003 and 2009.

Two types of departments are distinguished: producing departments and non-producing departments. The first group is composed of departments in which gold exploitation existed before 2009. Non-producing departments are those which did not host any mining activities before that time. Producing departments are not only those hosting industrial gold mining as it is in previous studies (for instance, see Loayza, Alfredo, and Rigolini 2013 and Zambrano, Robles, and Laos 2014) but also those with artisanal mining activities. We do this in order to account for both artisanal and small-scale mining when estimating the impact of gold exploitation on population living standards. Despite its low contribution in terms of production, artisanal mining is still an important phenomenon throughout the country. It is therefore relevant to take it into account in the analysis.

We consider the departments which hosted artisanal mining and for which licenses have been attributed to the holders to formalize small-scale mining activities. Because there are more than 200 artisanal mining licenses, we select only those licenses attributed before 2010. Finally, the sample is composed of 45 producing departments of which 5 departments host industrial mining, 156 departments are non-producing departments. Producing departments are considered the treatment group and non-producing departments the control group.[13]

4.4 Empirical strategy

Our identification strategy relies on the assumption that 2003 refers to a period before the formal gold mining extraction. In fact, during that time, the government reformed its mining law in order to attract foreign direct investments in the gold sector for the purpose of developing a large scale mining industry. As shown in Figure 3, the 2009 year has seen an increase in gold production and is considered as a year of gold expansion. We exploit this source of variation in

[13] Following Loayza, Alfredo, and Rigolini (2013), we could distinguish between three categories of departments: producing departments in which there existed a gold exploitation before 2009, non-producing departments in producing provinces and non-producing departments in non-producing provinces. This approach is used in the Appendix for the purpose of robustness checks.

order to assess the effect of gold exploitation.

As one recall here, our objective is to estimate the impact of gold mining exploitation on outcomes, as denoted by $Y_{1.1} - Y_0$ and $Y_{1.0} - Y_0$ in the theoretical model. Precisely, we plan to estimate $E(Y_1 - Y_0)$ conditional on some retained set of covariates, and where Y_1 is simply the value of Y when $\mathbf{1}_D = 1$ and Y_0 is the value of Y when $\mathbf{1}_D = 0$. Thus, the objective here is to assess the average effect of the rapid expansion in gold extraction on some specific socioeconomic outcomes in the producing departments.

The common raised problem with the impact evaluation studies is the selection bias, and where the treated group differs by their characteristics on the control group. The other usual econometric problem is the endogeneity that may exists when the explanatory variables are correlated with the error term and especially the specific characteristics of the analyzed entity, *viz*, the department in our case. Different econometric approaches can be used to estimate such effect of boom in gold extraction. According to the panel form of the data we use, difference-in-differences (DID) appears the most appropriate one. This econometric specification can be simplified in one linear regression model. Formally, our basic DID model is given by:

$$Y_i = \alpha + \gamma t_i + \beta' X_i + \delta D_i + \theta t_i \cdot D_i + u_i, \tag{7}$$

where Y_i refers to a given outcome of department i, such as, the headcount ratio, the poverty gap, the inequality index (for instance the Gini coefficient), the schooling rate and child labor; t_i is a binary time indicator; D_i is a dummy variable that it is equal to 1 if the department i is producing gold and 0 otherwise; X_i is a set of department characteristics (or covariates) and u_i represents the error terms. We assume that the error terms u_i are independent and identically distributed.

In this model, θ is the DID estimate of the average effect of gold extraction on the outcome variable, the usual parameter of interest. The intercept α refers to the constant effect for the control group in 2003 and the coefficient γ is the time trend effect common to treatment and control groups. δ is the effect of being targeted for the treatment while the vector β contains the parameters of the covariates for the two groups.

As said above, a main concern in this analysis is that the departments that produce gold could

be different from the departments that do not produce gold and the fact that this may be correlated with the outcome variable. The main advantage of using the DID model is that it allows controlling for time-invariant unobserved heterogeneity. According Lechner (2010), there is no need to control for all confounding variables in the case of DID estimation. However, it is based on the key identifying assumption that the outcome variable in producing and non-producing departments would follow the same time trends in the absence of gold extraction. This is often refers to as the common trend assumption in the literature. While there is no formal test to directly verify this assumption, it is common to test whether the time trends in the control and treatment groups were the same in the period prior to the treatment.

When the vector X includes variables that vary across both departments and time, the linear regression (7) can be rewritten as:

$$Y_{it} = \alpha_i + \gamma t + \beta' X_{it} + \theta D_{it} + u_{it}, \tag{8}$$

where Y_{it} is the outcome variable of the department i in year t; α_i is a department fixed effect; t is a binary time indicator; $D_{it} \equiv t \times D_i$ and u_{it} is the idiosyncratic error terms assumed to be heteroscedastic.[14] Because gold extraction present in one department could affect neighboring departments, we use robust estimations clustered at the department level to avoid potential bias in estimations of the standard errors. In this paper, we rely on the specification (8) as the main econometric model.

As above, θ is the DID estimate of the effect of gold exploitation on the outcome variables. The advantage of dealing with the specification (8) is that one can also consider the case of random-effects (RE) estimation. The related model is given by:

$$Y_{it} = \alpha + \gamma t + \beta' X_{it} + \delta D_i + \theta D_{it} + \varepsilon_{it}, \tag{9}$$

where $\varepsilon_{it} = \eta_i + u_{it}$ and η_i is a department fixed effect. Notice that in the case of the RE

[14] Galiani, Gertler, and Schargrodsky (2005) use a similar specification based on municipalities to assess the effect of the privatization of water services on child mortality in Argentina. Given that their analysis includes several years, they add a time fixed effect in the model.

model, the set of covariates X_{it} also includes all time-invariant characteristics not presented in (9). Although one can overcome the endogeneity bias due to omitted variables and potential correlation between the department characteristics and some regressors by using the fixed-effects (FE) model, the latter cannot be used to investigate the effect of a time-invariant variable whatever this variable is of great policy interest or not. Nonetheless, the Hausman test can be used to test for statistically significant differences in the coefficients on the time-varying explanatory variables as it is common in empirical work.

Yet, a major shortcoming of the standard Hausman test is that it requires homoscedasticity and it cannot include time fixed effects. Therefore such a test cannot be used in the presence of heteroscedasticity. Wooldridge (2010) proposes a regression-based approach due to Mundlack (1978) as an alternative to the standard Hausman test in choosing between an RE model and an FE model. This is given by the following equation:

$$Y_{it} = \alpha + \gamma t + \beta' X_{it} + \delta D_i + \theta D_{it} + \lambda' \bar{X}_i + u_{it}, \tag{10}$$

where $\bar{X}_i = (1/T) \sum_t X_{it}$.

The equation (10) can be estimated by pooled OLS using cluster-robust standard errors to allow for heteroscedasticity. Testing $H_0 : \lambda = 0$ using a robust Wald statistic is a way to test for the uncorrelatedness of the department fixed effects. We follow the above approach in the empirical analysis.

For a matter of robustness, we estimate the effect of gold exploitation on our set of outcomes using the OLS model of Loayza, Alfredo, and Rigolini (2013). This model is based on a cross-sectional analysis where the outcome variables of 2003 are covariates in order to control for differences in department characteristics in 2003, prior to the gold mining boom. The outcome variables of 2009 are the main variables of interest. Formally, the model is given by the simple regression:

$$Y_i = \alpha + \beta' X_i + \theta D_i + u_i, \tag{11}$$

where Y_i is the outcome of department i, D_i is a dummy variable that it is equal to 1 if the

department i is producing gold and 0 otherwise; X_i is a set of department characteristics (or covariates) which also includes the outcomes of 2003 and u_i is the error term. The parameter θ is the impact of gold exploitation on producing department compare to non-producing departments in the same province.

5 Application and results

In this section, we present the results obtained from the descriptive statistics and the estimations of our model. Table 3 describes the variables used in the empirical analysis. In order to ensure comparability between the two surveys regarding the estimation of poverty rates and inequality, household per capita expenditure of 2003 survey has been re-estimated using the poverty map approach.[15]

All the variables are computed as the mean value of the department. The schooling variable is the net primary school enrolment rate. Based on the official definition of child labor in Burkina Faso, and in order to accommodate both the 2003 and 2009 surveys, we consider children aged from 6 to 14 for child labor. Table 4 provides descriptive statistics of the outcomes variables. Producing departments are likely to be less poor than non-producing departments. However, they exhibit lower schooling rates and have a higher proportion of child workers compare to the departments that do not produce gold.

In Table 5, we present some statistics related to covariates. This reveals that producing departments are, on average, of greater geographical size than are non-producing departments. This statistical regularity has been pointed out for the case of Peru by Loayza, Alfredo, and Rigolini (2013). A simple mean-comparison test shows that the difference is significant between producing and non-producing departments regarding geographical area. Nevertheless, our approach allows us to control for this difference by including the area of the department as a covariate.

The main results are presented in Tables 6, 7, 8 and 9. The auxiliary test displayed in Table 10 suggests the use of the RE model for all outcomes. While homoscedasticity is not rejected in

[15] For more details related to this approach, see for example World Bank (2013) and Elbers, Lanjouw, and Lanjouw (2003).

the case of schooling, the standard Hausman test also suggests the RE model as the appropriate empirical strategy. This is also supported by the auxiliary test.

Some consistent findings emerge from theses tables. First, the headcount ratio and the poverty gap respectively decrease by 8 percentage points and 4 percentage points more in producing than in non-producing departments. The average per capita expenditure is 12 percent higher than non-producing ones.

Second, we do not find an effect of gold extraction on inequality and schooling except in Tables 13 and 14 where we estimate the effect using Loayza, Alfredo, and Rigolini (2013)'s approach for the purpose of robustness checks. This may appear somewhat surprising in the case of Burkina Faso, especially when considering the last outcome (schooling). The year 2013 registered a particularly sharp decline in the number of primary school students — those who attended the certificate of primary education exam (MEBA 2014).[16] Moreover, an analysis based on school dropouts show that this phenomenon is worsened by gold exploitation as the estimated effect is positive and highly significant.

Third, the measured impact is positive and not significant for child labor. However, the positive impact is consistent with the observed increase in child labor in mining sites. Indeed, the magnitude of child labor in mining sites, especially in artisanal mining, is a real concern in Burkina Faso. Significantly more than 100,000 children are employed in these sites, according to UNICEF (2014) estimates. Given that parents are primarily responsible for their children education, a use of mutual enforcement strategies including building knowledge on child labor issues as well as involvement of parents and children themselves could lead to positive results in the fight against child labor. It would also be useful to include child labor issues in the primary school curriculum.

Fourth, the average per capita expenditure positively affects schooling and negatively affects child labor according to our results obtained in all tables. This is in line with our results in and children themselves could lead to positive results in the fight against child labor. It would also the theoretical analysis. When parents get higher income, they do not need to ask their children to

[16] A recent investigation reveals that child labor is the main cause of not attending school in areas close to mining sites. See for example Zerbo and Ouédraogo (2014).

work and accordingly, their children are able to spend more time at school. be useful to include child labor issues in the primary school curriculum.

Regarding covariates, geographic subdivisions captured by the variable "proportion of areas with plots" has always a significant effect on the outcome variables. The result is robust to all specifications estimated to date. Increased subdivision size is associated with improvements in average living standards: less poverty, larger consumption, higher schooling rates and a lower fraction of children engaged in child labor. The only drawback is that larger geographic subdivisions contribute to rising inequality. One might be tempted to interpret these results as "direct effects". However, the economic argument would require at least several channels through which such effects operate. For instance, the increase in geographic subdivisions would lead to urbanization development and thereby economic growth and poverty reduction. Regarding schooling and child labor, the linkages are less perceptible. It is also noteworthy to report that in case of an industrial mining (which usually occurs in rural areas), companies have the legal obligation to relocate displaced populations in new subdivided areas. This contributes to improving basic services and infrastructure in rural areas.

The area of residence also matters in this analysis. Except child labor, the proportion of people living in rural areas significantly affects the outcome variables with the expected signs. This is consistent with the findings largely shared in studies: poverty is a rural phenomenon and inequality is less exacerbated in rural areas than in urban ones. The average expenditure is lower in rural areas.

Our analysis also allows us to confirm what is already pointed out by Werthmann (2009) in the case of Burkina Faso: the presence of women and girls in mining sites which are frequently represented by men.[17] The findings of Tables 6, 7, 8 and 9 show that an increase in the proportion of females in the department increases child labor. In other words, these findings seem to support Werthmann (2009)'s argument.

Regarding the context of artisanal extraction in Burkina Faso, we think that there is need to

[17]This study based on gold mining focuses on informal and artisanal mining and highlights the reasons that may explain why women and girls are present in mining camps.

regulate this activity, not only because of child labor but also because of the environmental degradation, health-related challenges and conflicts that result from gold exploitation. These adverse effects could mitigate the positive impacts of gold extraction on the average living standards of producing departments. However, due to lack of information in the data, our analysis does not take into account such limitations.

In the Appendix, we provide some results obtained with the approach of Loayza, Alfredo, and Rigolini (2013). They are presented in Tables 13 and 14. On average, producing departments have better living standards than the other departments: lower headcount ratio and poverty gap and higher consumption. Except for inequality and the poverty gap where the effect becomes non-significant, the results remain the same after the inclusion of provincial dummies and even with less covariates. As other robustness checks, we exclude from the panel data all the departments that host industrial mining to restrict the sample to artisanal mining. The results are given in Tables 11 and 12. The effect is statistically significant on headcount ratio and expenditure respectively at the 10% and 5% level. Artisanal mining may also contribute to increase households consumption. Our findings in the theoretical model support this result. Although, the effect on poverty gap is no longer statistically significant at the 10% level when the sample is restricted to artisanal mining, the signs of the coefficients of interest remain as expected.

6 Conclusions and policy implications

This paper examines the impact of gold exploitation on living standard outcomes in Burkina Faso. Using microdata from the 2003 and 2009 household surveys and administrative data, our results show that gold mining extraction has a positive impact on average per capita household expenditures. This is consistent with the theoretical analysis. Gold mining also contributes to reducing poverty. The panel data and the used econometric models allow interpreting such effects as causal. The theoretical model shows that gold mining exacerbates inequality and child labor and has a negative effect on schooling. These expectations were confirmed by the empirical analysis, except the case of schooling. However, the estimates were not statistically significant for

inequality, schooling and child labor. This can be explained *inter alia* by the nature of the units of analysis and then the relatively low size of the sample.

The derived theoretical and empirical results in this study highlight the effects of gold mining boom. Gold extraction can help reducing poverty and increasing average income. This suggests that a policy supporting gold extraction could lead to better average living standards in Burkina Faso.

However, gold exploitation may increase inequality in Burkina Faso. It may also have a negative effect on schooling and may have scaled up child labor in gold mining sites or in areas close to mining activities. The Government of Burkina Faso with the support of UNICEF and some non-governmental organizations have already initiated and implemented several programs in the most affected regions to get children out of mining sites. The objective is to encourage children to return to school, to train those who have worked in mines and to support young people in creating small enterprises and income generating activities. Such measures could contribute to increasing school attendance. However given the magnitude of the phenomenon, challenges still remain. An effort has been done by the Transitional Government to strengthen enforcement of existing child labor laws in both artisanal and industrial mining sites. Indeed, the 2015 Mining Code includes articles that provides for penalties for child labor law violations.

In order to prevent the negative outcomes which could undermine the potential for poverty reduction, a policy supporting gold extraction should be paired with programs or strategies against worsening inequality, school dropouts and child labor.

For further research, it would be important to integrate environmental and health issues in the empirical analysis if data are available. This would be an interesting and useful avenue given that the resource curse literature has not yet explored this question in line with the environmental and health challenges.

Table 1: Results for the theoretical model. $\theta \equiv \frac{\beta\gamma}{\alpha+\beta-\beta\gamma}$. w_c is the child wage in mines, w_i is parents' wage in industrial mines, w_x is parents' wage in other activity, t_c is the total time available for the child, t_a is the total time available for parents.

	If $w_c \leq \theta\frac{t_a}{t_c}w_x$	If $\theta\frac{t_a}{t_c}w_x \leq w_c \leq \theta\frac{t_a}{t_c}w_i$	If $w_c \geq \theta\frac{t_a}{t_c}w_i$
e_{c0} (schooling in non prod. Dep)	t_c	t_c	t_c
$e_{c_{1.0}}$ (schooling in artisanal prod.)	t_c	$\frac{\beta\gamma}{(\alpha+\beta)w_c}\left(\overset{(-)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$	$\frac{\beta\gamma}{(\alpha+\beta)w_c}\left(\overset{(-)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$
$e_{c_{1.1}}$ (schooling in industrial prod.)	t_c	t_c	$\frac{\beta\gamma}{(\alpha+\beta)w_c}\left(\overset{(-)}{w_c}\ t_c + \overset{(+)}{w_i}\ t_a\right)$
c_0 (consumption in non prod. Dep.)	$\frac{\alpha\overset{(+)}{w_x}t_a}{\alpha+\beta-\beta\gamma}$	$\frac{\alpha\overset{(+)}{w_x}t_a}{\alpha+\beta-\beta\gamma}$	$\frac{\alpha\overset{(+)}{w_x}t_a}{\alpha+\beta-\beta\gamma}$
$c_{1.0}$ (consumption in artisanal prod.)	$\frac{\alpha\overset{(+)}{w_x}t_a}{\alpha+\beta-\beta\gamma}$	$\frac{\alpha}{\alpha+\beta}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$	$\frac{\alpha}{\alpha+\beta}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$
$c_{1.1}$ (consumption in industrial prod.)	$\frac{\alpha\overset{(+)}{w_i}t_a}{\alpha+\beta-\beta\gamma}$	$\frac{\alpha\overset{(+)}{w_i}t_a}{\alpha+\beta-\beta\gamma}$	$\frac{\alpha}{\alpha+\beta}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_i}\ t_a\right)$
y_0 (school good in non prod. Dep.)	$\frac{\beta(1-\gamma)\overset{(+)}{w_x}t_a}{p_0(\alpha+\beta-\beta\gamma)}$	$\frac{\beta(1-\gamma)\overset{(+)}{w_x}t_a}{p_0(\alpha+\beta-\beta\gamma)}$	$\frac{\beta(1-\gamma)\overset{(+)}{w_x}t_a}{p_0(\alpha+\beta-\beta\gamma)}$
$y_{1.0}$ (school good in artisanal prod.)	$\frac{\beta(1-\gamma)\overset{(+)}{w_x}t_a}{p_1(\alpha+\beta-\beta\gamma)}$	$\frac{\beta(1-\gamma)}{(\alpha+\beta)p_1}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$	$\frac{\beta(1-\gamma)}{(\alpha+\beta)p_1}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_x}\ t_a\right)$
$y_{1.1}$ (consumption in industrial prod.)	$\frac{\beta(1-\gamma)\overset{(+)}{w_i}t_a}{p_1(\alpha+\beta-\beta\gamma)}$	$\frac{\beta(1-\gamma)\overset{(+)}{w_i}t_a}{p_1(\alpha+\beta-\beta\gamma)}$	$\frac{\beta(1-\gamma)}{(\alpha+\beta)p_1}\left(\overset{(+)}{w_c}\ t_c + \overset{(+)}{w_i}\ t_a\right)$

Table 2: Expected effects of gold mining

Interest variables	**The effect of mining**
Schooling	$-$
Consumption	$+$
Education goods	$+$
Inequality aggravation	$+$ or No effect

Table 3: Definition of variables in the dataset

Outcomes variables	*Description*
Headcount ratio	Department poverty rate
Poverty gap	Department poverty gap
Inequality	Gini coefficient of the department
Average per capita expenditure	Mean of per capita yearly expenditures of the department
Schooling rate	Net primary school enrollment rate (aged 6-12 years)
Child labor	Proportion of workers aged 6-14 years
Covariates	
Producing department*year	Dummy variable = 1 if the department holds gold extraction in 2009
Producing department	Dummy variable = 1 if the department holds gold extraction
Year	Dummy variable = 1 for 2009 and 0 otherwise
Basic services and area characteristics	
Proportion with access to drinking water	Proportion of people located less than 15 mn from drinking water
Proportion with access to food market	Proportion of people located less than 15 mn from market for agricultural produce
Proportion with access to primary school	Proportion of people located less than 15 mn from a primary school
Proportion with access to secondary school	Proportion of people located less than 30 mn from a secondary school
Proportion with access to health center	Proportion of people located less than 30 mn from a health service
Proportion of areas with plots	Proportion of geographic subdivisions
Log of area	Logarithm of department area (in square kilometers)
Proportion of rural area	Proportion of people living in rural area in the department
Economic and demographic characteristics	
Household head or spouse is self-employed	Proportion of household heads or spouses who are self-employed
Experience food problems	Proportion of households who experienced food problems during the year
Dropped for lack of ways	Proportion of people who dropped out of school because of lack of ways
Mining revenue	Logarithm of the government transfer of mining revenue to the department
Dropped out of school	Proportion of people who dropped out of school
Economic situation of the household (HH)	Proportion of households who think their situation has improved
Average age of population	Mean age of the department
Proportion of women	Proportion of women in the department
Log of population	Logarithm of the population of the department

Source: *EBCVM* 2003, *EICVM 2009* and administrative data from the Ministry of Mines and Energy.

Table 4: Summary statistics of outcome variables

	2003						2009					
	Producers		Non producers		All		Producers		Non producers		All	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Headcount ratio (%)	51.99	14.72	54.89	17.41	54.24	16.86	42.88	19.80	47.02	21.16	46.07	20.89
Poverty Gap (%)	18.96	9.34	21.15	9.89	20.67	9.80	13.48	9.57	15.35	9.97	14.92	9.89
Gini index	0.36	0.06	0.39	0.08	0.38	0.07	0.33	0.08	0.34	0.09	0.34	0.09
Average expenditure	227,869	64,414	235,806	91,022	234,037	85,727	190,817	63,821	189,151	69, 635	189,535	68,182
Schooling rate (%)	15.51	13.24	28.29	21.31	25.44	20.47	23.13	19.01	37.28	27.75	34.01	26.63
Child labor (%)	53.26	26.83	44.44	27.31	46.41	27.39	68.34	17.21	52.67	29.93	56.28	28.27
Observations	45		156		201		45		156		201	

Source: Produced by the authors using the 2003-2009 data. Std. dev. stands for standard deviation.

Table 5: Summary statistics of covariates

Variable	Producers	Non producers	All
Proportion with access to drinking water (%)	69.63	72.40	71.78
	(20.11)	(23.09)	(22.46)
Proportion with access to food market (%)	19.13	27.57	25.68
	(18.49)	(26.92)	(25.50)
Proportion with access to primary school (%)	35.26	36.10	35.91
	(25.16)	(27.38)	(26.87)
Proportion with access to secondary school (%)	12.20	19.24	17.67
	(19.69)	(26.13)	(24.99)
Proportion with access to health center (%)	24.73	35.13	32.80
	(24.73)	(32.69)	(31.36)
Proportion of areas with plots (%)	10.84	11.85	11.62
	(22.90)	(23.55)	(23.39)
Area (square km)	1,402	825.02	954.19
	(1,014)	(624.14)	(767.10)
Proportion of rural area (%)	90.11	93.01	92.36
	(23.03)	(20.79)	(21.32)
Household head or spouse is self-employed (%)	23.92	23.84	23.86
	(10.00)	(9.44)	(9.55)
Experience food problems (%)	64.57	66.53	66.09
	(21.82)	(23.52)	(23.14)
Dropped for lack of ways (%)	2.52	3.07	2.95
	(3.00)	(3.46)	(3.36)
Mining revenue	329,818	96,144	148,459
	(870,778)	(477,950)	(595,793)
Dropped out of school (%)	3.45	4.17	4.01
	(3.43)	(4.14)	(4.00)
Household situation improved (%)	57.44	60.25	59.62
	(20.95)	(22.27)	21.99
Average age	20.97	21.25	21.19
	(2.02)	(2.19)	(2.15)
Proportion of women (%)	51.12	51.66	51.54
	(3.15)	(3.84)	(3.70)
Population	57,070	56,005	56,243
	(31,955)	(117,478)	(104,548)
Observations	90	312	402

Source: Produced by the authors using the 2003-2009 data (standard deviation in parentheses).

Table 6: DID estimation

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
DID	-0.0851**	-0.0389*	0.0118	0.127**	0.0165	0.0272
Producing department	-0.00339	-0.000166	0.00222	0.0125	-0.0307*	0.0181
Year of the survey	-0.192***	-0.130***	-0.0786***	-0.0960**	-0.0101	0.279***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.103*	0.0413	-0.0436**	-0.201**		
- Proportion with access to food market	0.0469	0.0325	-0.00318	-0.115*		
- Proportion with access to primary school	-0.0464	-0.0309	0.0190	0.122*	0.0960***	
- Proportion with access to secondary school	-0.105	-0.0504	0.0187	0.142	0.158***	
- Proportion with access to health center	0.0299	0.00493	-0.000876	-0.00143		
- Proportion of areas with plots	-0.133***	-0.0608***	0.0512**	0.340***	0.178***	-0.231***
- Log of area	-0.0341**	-0.0226***	0.00305	0.0553***		
- Rural area	0.185***	0.0814***	-0.0912***	-0.459***	-0.151***	0.0942
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-1.001***	-0.610***	-0.00648	1.679***	-0.132	0.856***
- Experience food problems	0.0331	0.0328	-0.00241	-0.0706		
- School drop due to lack of ways	0.199	0.0640	0.0229	-0.439		
- Mining revenue	0.00272	0.00190	0.00202**	-0.000102	0.000431	
- Average age of population	-0.00700	-0.00437*	-0.00197	0.00666		
- Log average expenditure					0.0224	-0.0152
- Dropped out of school					0.821***	-0.422*
- Economic situation of the HH						0.157***
- Proportion of women						0.802***
- Log of population of the department						-0.0324*
Constant	1.004***	0.529***	0.484***	11.75***	0.00621	0.238
Observations	402	402	402	402	402	402
R^2	0.250	0.271	0.286	0.496	0.408	0.304

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.

* p<0.10, ** p<0.05, *** p<0.010

Table 7: DID estimation with regional dummies

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
DID	-0.0790*	-0.0362	0.0126	0.120**	0.0181	0.0347
Producing department	-0.0150	-0.00436	0.000161	0.0135	-0.0204	-0.00531
Year of the survey	-0.190***	-0.131***	-0.0791***	-0.100**	-0.0111	0.279***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.0637	0.0203	-0.0388*	-0.133*		
- Proportion with access to food market	0.0336	0.0289	-0.00521	-0.0997		
- Proportion with access to primary school	-0.0420	-0.0299	0.0189	0.113*	0.121***	
- Proportion with access to secondary school	-0.0895	-0.0373	0.0210	0.113	0.148***	
- Proportion with access to health center	0.0197	-0.000530	0.00153	0.0225		
- Proportion of areas with plots	-0.150***	-0.0810***	0.0481**	0.383***	0.153**	-0.154***
- Log of area	-0.00580	-0.0115*	0.00572	0.0168		
- Rural area	0.193***	0.0833***	-0.0894***	-0.458***	-0.138***	0.106*
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-0.995***	-0.613***	-0.00976	1.624***	-0.165	0.989***
- Experience food problems	-0.0127	0.00713	-0.00674	-0.00570		
- School drop due to lack of ways	0.0646	-0.0138	0.00962	-0.169		
- Mining revenue	0.00272	0.00205	0.00189*	-0.00115	0.00126	
- Average age of population	-0.00163	-0.00166	-0.00226	-0.000830		
- Log average expenditure					0.0665*	-0.0735
- Dropped out of school					0.532**	-0.409*
- Economic situation of the HH						0.151***
- Proportion of women						0.707**
- Log of population of the department						-0.0329**
Region:						
- Hauts Bassins	0.0300	0.0220	0.00445	-0.000835	-0.103***	0.0490
- Boucle Du Mouhoun	0.00676	0.0292	-0.00747	-0.0487	-0.0585	0.00566
- Sahel	-0.117***	-0.0264	0.00614	0.192***	-0.114***	-0.104**
- Est	0.123***	0.0832***	-0.00431	-0.189***	-0.0964***	-0.0716
- Sud Ouest	0.134***	0.0911***	0.00829	-0.185***	0.0280	-0.0148
- Centre Nord	-0.0945***	-0.0390***	0.0181	0.217***	-0.0966***	0.179***
- Centre Ouest	0.0444	0.0480***	-0.00154	-0.0925**	-0.0109	-0.00158
- Plateau Central	0.0444*	0.0244*	0.00991	-0.0680*	0.0413	-0.159***
- Nord	0.130***	0.0787***	0.00636	-0.159***	-0.0571*	0.0357
- Centre Est	0.0946***	0.0637***	0.00589	-0.133***	-0.0307	-0.0914**
- Centre	0.0539**	0.0741***	0.0365***	-0.103**	0.0786	-0.0649
- Cascades	-0.0524	-0.00471	-0.00601	0.0638	-0.0267	-0.0207
Constant	0.725***	0.397***	0.468***	12.13***	-0.488	0.969
Observations	402	402	402	402	402	402
R^2	0.398	0.411	0.297	0.618	0.473	0.407

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.
* p<0.10, ** p<0.05, *** p<0.010

Table 8: Fixed-effects estimation

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Producing department*year	-0.0835**	-0.0368*	0.0112	0.124**	0.00717	0.0559
Year of the survey	-0.199***	-0.129***	-0.0738***	-0.0817	-0.00842	0.299***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.0653	0.0107	-0.0463	-0.130		
- Proportion with access to food market	0.00568	0.0349	-0.00534	-0.110		
- Proportion with access to primary school	-0.0333	-0.0316	0.00817	0.118	0.100**	
- Proportion with access to secondary school	-0.0475	-0.0337	0.0121	0.0639	0.136**	
- Proportion with access to health center	0.0433	0.0104	-0.00481	-0.0185		
- Proportion of areas with plots	-0.203***	-0.106***	0.0352	0.466***	0.132*	-0.0890
- Rural area	0.0590	0.00348	-0.0850**	-0.259	-0.188***	0.0529
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-1.063***	-0.638***	-0.0438	1.751***	-0.158	1.179***
- Experience food problems	0.0752	0.0417	0.0160	-0.0841		
- School drop due to lack of ways	0.309	0.176	0.0763	-0.582		
- Mining revenue	0.00222	0.00139	0.00128	-0.000403	0.00270	
- Average age of population	-0.00322	-0.00120	-0.000643	-0.000514		
- Log average expenditure					0.0926**	-0.0873
- Dropped out of school					0.603*	-0.524
- Economic situation of the HH						0.206***
- Proportion of women						0.787*
- Log of population of the department						-0.0565*
Constant	0.829***	0.406***	0.477***	12.03***	-0.800	1.281
Observations	402	402	402	402	402	402
R^2	0.218	0.263	0.251	0.551	0.300	0.331
Wald test for homoscedasticity (*p*-value)	0.000	0.000	0.000	0.000	1.000	0.000

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.

* p<0.10, ** p<0.05, *** p<0.010

Table 9: Random-effects estimation

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Producing department*year	-0.0853**	-0.0389*	0.0118	0.127**	0.0156	0.0280
Producing department	-0.00358	-0.000197	0.00222	0.0126	-0.0320*	0.0181
Year of the survey	-0.194***	-0.130***	-0.0786***	-0.0923*	-0.00954	0.280***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.0984*	0.0394	-0.0436**	-0.191**		
- Proportion with access to food market	0.0417	0.0328	-0.00318	-0.115*		
- Proportion with access to primary school	-0.0448	-0.0310	0.0190	0.122*	0.0965***	
- Proportion with access to secondary school	-0.0979	-0.0495	0.0187	0.131	0.155***	
- Proportion with access to health center	0.0319	0.00532	-0.000876	-0.00398		
- Proportion of areas with plots	-0.143***	-0.0640***	0.0512**	0.360***	0.173***	-0.227***
- Log of area	-0.0335**	-0.0225***	0.00305	0.0548***		
- Rural area	0.177***	0.0786***	-0.0912***	-0.443***	-0.154***	0.0937
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-1.012***	-0.613***	-0.00648	1.695***	-0.132	0.865***
- Experience food problems	0.0379	0.0332	-0.00241	-0.0712		
- School drop due to lack of ways	0.202	0.0673	0.0229	-0.441		
- Mining revenue	0.00272	0.00190	0.00202**	-0.000343	0.000637	
- Average age of population	-0.00645	-0.00416*	-0.00197	0.00548		
- Log average expenditure					0.0289	-0.0169
- Dropped out of school					0.800***	-0.425*
- Economic situation of the HH						0.159***
- Proportion of women						0.799***
- Log of population of the department						-0.0330*
Constant	1.000***	0.528***	0.484***	11.76***	-0.0685	0.262
Observations	402	402	402	402	402	402

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.

* p<0.10, ** p<0.05, *** p<0.010

Table 10: Auxiliary test (Mundlak, 1978)

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Wald for $\lambda = 0$	7.56	11.4	6.84	8.16	11.60	11.20
p-value	0.8185	0.4949	0.8680	0.7725	0.1699	0.1906
R^2	0.2627	0.2868	0.2956	0.5056	0.4206	0.3211
Observations	402	402	402	402	402	402

Source: Produced by the authors using the 2003-2009 data.

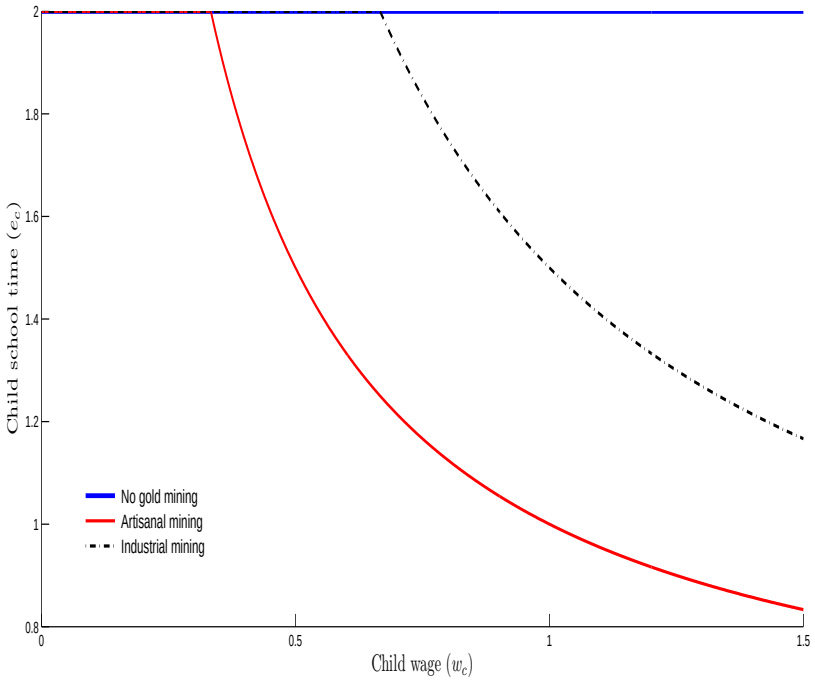

Figure 1: Child schooling time as a function of child wage. We set $A = 1$, $\alpha = \beta = 0.5$, $t_c = 2$, $t_a = 1$, $w_i = 4$, $w_x = 2$, $p_0 = p_1 = 1$.

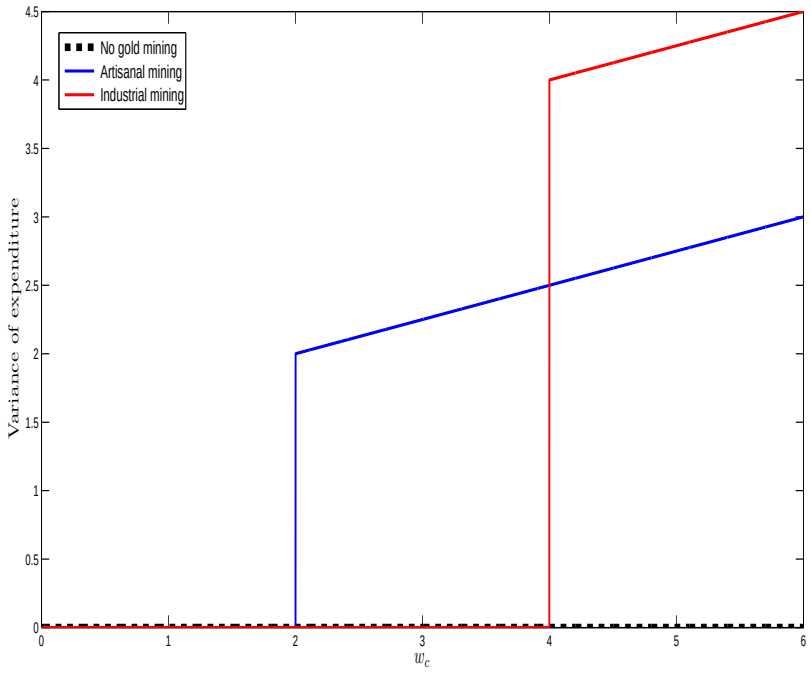

Figure 2: Inequality as a function of child wage. We set $A = 1$, $\alpha = \beta = 0.5$, $t_c = 1$, $t_a = 1$, $w_i = 12$, $w_x = 6$, $p_0 = p_1 = 1$.

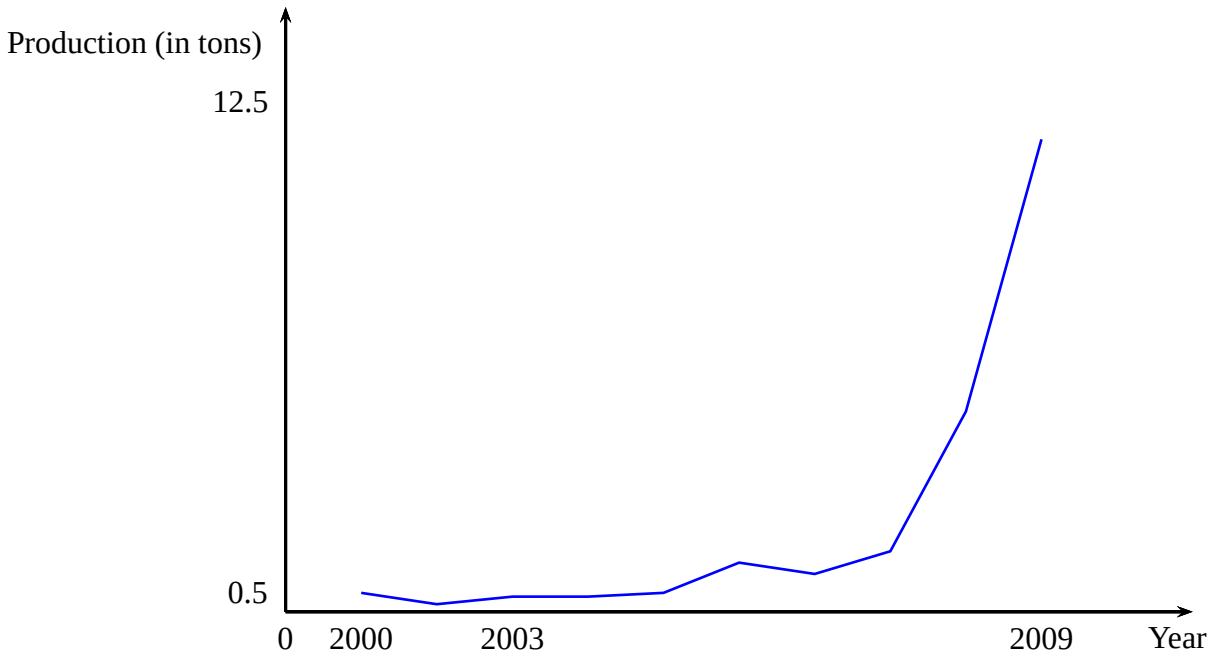

Figure 3: Evolution of gold production between 2000 and 2009

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A Results of the theoretical model

The optimal value for l_a is straightforward. If $(w_i \mathbf{1}_{D_I} + w_a (1 - \mathbf{1}_{D_I})) \mathbf{1}_D - w_x > 0$ then $l_a = t_a$, and if $(w_i \mathbf{1}_{D_I} + w_a (1 - \mathbf{1}_{D_I})) \mathbf{1}_D - w_x < 0$ then $l_a = 0$. The Lagrangian of the problem (6) is

$$\begin{aligned}\mathfrak{L} &= \alpha \ln c + \beta \ln A + \beta\gamma \ln e_c + \beta(1-\gamma) \ln y \\ &+ \lambda \left[w_c \mathbf{1}_D t_c + \left((w_i \mathbf{1}_{D_I} + w_a (1 - \mathbf{1}_{D_I})) \mathbf{1}_D - w_x \right) l_a + w_x t_a \right. \\ &\left. - c - py - w_c \mathbf{1}_D e_c \right] + \mu (t_c - e_c) \end{aligned} \tag{12}$$

The first order conditions are:

$$\frac{\partial \mathfrak{L}}{\partial c} = \frac{\alpha}{c} - \lambda = 0 \tag{13}$$

$$\frac{\partial \mathfrak{L}}{\partial y} = \frac{\beta(1-\gamma)}{y} - \lambda p = 0 \tag{14}$$

$$\frac{\partial \mathfrak{L}}{\partial e_c} = \frac{\beta\gamma}{e_c} - \lambda w_c \mathbf{1}_D - \mu = 0 \tag{15}$$

Let's consider $\mu > 0$. So $e_c = t_c$. From (13) and (14) we find that $y = \frac{\beta(1-\gamma)c}{\alpha p}$. Using the first constraint which is bounded, we can find that

$$c = \frac{\alpha \left[\left((w_i \mathbf{1}_{D_I} + w_a (1 - \mathbf{1}_{D_I})) \mathbf{1}_D - w_x \right) l_a + w_x t_a \right]}{\alpha + \beta - \beta\gamma} \tag{16}$$

We can then find c_0, $c_{1.0}$, $c_{1.1}$, y_0, $y_{1.0}$, and $y_{1.1}$. We then find the expression of μ for each of the three cases we consider, i.e, μ_0, $\mu_{1.0}$, and $\mu_{1.1}$. We have

$$\mu_0 = \frac{\beta\gamma}{t_c} > 0 \tag{17}$$

$$\mu_{1.0} = \frac{\beta\gamma}{t_c} - \frac{(\alpha + \beta - \beta\gamma) w_c}{w_x t_a} \tag{18}$$

$$\mu_{1.1} = \frac{\beta\gamma}{t_c} - \frac{(\alpha + \beta - \beta\gamma) w_c}{w_i t_a} \tag{19}$$

$\mu_{1.0} > 0$ if $w_c \leq \theta \frac{t_a}{t_c} w_x$ and $\mu_{1.1} > 0$ if $w_c \leq \theta \frac{t_a}{t_c} w_i$. So, depending on the values of the parameters, we can easily identify the solutions that are valid.

Let's now consider $\mu = 0$. So, we should have $e_c < t_c$. We can solve the first other conditions and check for $e_c < t_c$.

B Predicted effect of gold mining

First case: $w_c \geq \theta \frac{t_a}{t_c} w_i$

It is easy to find that $e_{c_0} > e_{c_{1.1}} > e_{c_{1.0}}$. Also, it is trivial to find $c_{1.1} > c_{1.0}$.

$\frac{c_{1.0}}{c_0} = \frac{\alpha+\beta-\beta\gamma}{\alpha+\beta} \left(\frac{w_c t_c}{w_x t_a} + 1 \right)$. We can check that $\frac{c_{1.0}}{c_0} > 1$ if $w_c \geq \theta \frac{t_a}{t_c} w_i$.

Depending on the prices, we follow the same procedure to compare y_0, $y_{1.0}$, and $y_{1.1}$. We can show that $y_{1.1} > y_{1.0}$.

Second case: $\theta \frac{t_a}{t_c} w_x \leq w_c \leq \theta \frac{t_a}{t_c} w_i$

We can prove that $y_{1.1} > y_{1.0}$.

$e_{c_0} = t_c$, $e_{c_{1.0}} < t_c$, and $e_{c_{1.1}} = t_c$. So $e_{c_{1.0}} < e_{c_{1.1}} = e_{c_0}$.

From our previous calculations, we have that $c_{1.0} > c_0$ and $c_{1.1} > c_0$.

We can show that $\frac{c_{1.0}}{c_{1.1}} > 1$ if

$$w_c > \theta \frac{t_a}{t_c} w_i + \frac{t_a}{t_c} \left(1 - \frac{w_x}{w_a} \right). \tag{20}$$

But (20) cannot hold because we are in the case where $w_c \leq \theta \frac{t_a}{t_c} w_i$. So $\frac{c_{1.0}}{c_{1.1}} \leq 1$.

Third case: $w_c \leq \theta \frac{t_a}{t_c} w_x$

$e_{c_0} = e_{c_{1.0}} = e_{c_{1.1}}$.

$c_0 = c_{1.0} < c_{1.1}$.

$y_{1.0} < y_{1.1}$.

C Gold exploitation and inequality in expenditure

The total expenditure is a random variable as it depends on α (random variable capturing the importance of consumption for the household). We see how the variance of the expenditure changes with gold exploitation. To that end, we use the Delta method by approximating the expenditure as a function of α. Let E_0', $E_{1.1}'$ and $E_{1.0}'$ be the first derivative with respect to α of E_0, $E_{1.1}$ and $E_{1.0}$ respectively. E_0, $E_{1.1}$ and $E_{1.0}$ stands for the total expenditure respectively in no producing, industrial, and artisanal mining. We have

$$Var(E_0) = \left[E_0'|_{\alpha=\bar{\alpha}}\right]^2 Var(\alpha). \tag{21}$$

$$Var(E_{1.1}) = \left[E_{1.1}'|_{\alpha=\bar{\alpha}}\right]^2 Var(\alpha). \tag{22}$$

$$Var(E_{1.0}) = \left[E_{1.0}'|_{\alpha=\bar{\alpha}}\right]^2 Var(\alpha). \tag{23}$$

First case: $w_c \geq \theta\frac{t_a}{t_c}w_i$

$$E_0' = 0, \quad E_{1.0}' = \frac{\beta\gamma}{(\alpha+\beta)^2}\left(w_c t_c + w_x t_a\right), \quad \text{and } E_{1.1}' = \frac{\beta\gamma}{(\alpha+\beta)^2}\left(w_c t_c + w_i t_a\right).$$

Since $w_i > w_x$, the proof ends.

Second case: $\theta\frac{t_a}{t_c}w_x \leq w_c \leq \theta\frac{t_a}{t_c}w_i$

We have

$$E_0' = 0, \quad E_{1.0}' = \frac{\beta\gamma}{(\alpha+\beta)^2}\left(w_c t_c + w_x t_a\right), \quad \text{and } E_{1.1}' = 0.$$

From the equations just above we can find the result.

Third case: $w_c \leq \theta\frac{t_a}{t_c}w_x$

We have

$$E_0' = E_{1.0}' = E_{1.1}' = 0.$$

D Tables

Table 11: DID estimation in case of no industrial mining

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
DID	-0.0779*	-0.0333	0.0202	0.129**	0.0158	0.0357
Producing department	0.00690	0.00197	-0.000306	-0.00137	-0.0312*	0.0146
Year of the survey	-0.193***	-0.130***	-0.0809***	-0.102**	-0.00876	0.281***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.101*	0.0380	-0.0472***	-0.199**		
- Proportion with access to food market	0.0573	0.0392	0.00249	-0.124*		
- Proportion with access to primary school	-0.0368	-0.0264	0.0211	0.114*	0.0971***	
- Proportion with access to secondary school	-0.102	-0.0484	0.0272	0.158*	0.159***	
- Proportion with access to health center	0.0252	0.00166	-0.00535	-0.00267		
- Proportion of areas with plots	-0.140***	-0.0648***	0.0452**	0.338***	0.176***	-0.233***
- Log of area	-0.0323**	-0.0215***	0.00257	0.0504**		
- Rural area	0.189***	0.0829***	-0.0901***	-0.461***	-0.149***	0.102*
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-0.994***	-0.606***	-0.0149	1.638***	-0.130	0.863***
- Experience food problems	0.0384	0.0325	-0.00381	-0.0735		
- School drop due to lack of ways	0.273	0.117	0.0647	-0.527		
- Mining revenue	0.00311	0.00208	0.00222**	-0.000215	0.000425	
- Average age of population	-0.00740	-0.00451*	-0.00209	0.00710		
- Log average expenditure					0.0263	-0.0144
- Dropped out of school					0.815***	-0.359
- Economic situation of the HH						0.144***
- Proportion of women						0.758**
- Log of population of the department						-0.0264
Constant	0.986***	0.521***	0.492***	11.80***	-0.0441	0.182
Observations	392	392	392	392	392	392
R^2	0.251	0.272	0.293	0.499	0.406	0.304

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.

* p<0.10, ** p<0.05, *** p<0.010

Table 12: Random-effects estimation in case of no industrial mining

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Producing department*year	-0.0779*	-0.0334	0.0202	0.129**	0.0147	0.0363
Producing department	0.00671	0.00195	-0.000306	-0.00109	-0.0324*	0.0146
Year of the survey	-0.195***	-0.130***	-0.0809***	-0.0977**	-0.00818	0.281***
Basic services and area characteristics:						
- Proportion with access to drinking water	0.0967*	0.0360	-0.0472***	-0.190**		
- Proportion with access to food market	0.0528	0.0398	0.00249	-0.124*		
- Proportion with access to primary school	-0.0372	-0.0270	0.0211	0.116*	0.0974***	
- Proportion with access to secondary school	-0.0950	-0.0472	0.0272	0.147	0.155***	
- Proportion with access to health center	0.0263	0.00175	-0.00535	-0.00411		
- Proportion of areas with plots	-0.150***	-0.0681***	0.0452**	0.356***	0.171***	-0.230***
- Log of area	-0.0317**	-0.0213***	0.00257	0.0500**		
- Rural area	0.182***	0.0801***	-0.0901***	-0.447***	-0.152***	0.102*
Economic and demographic characteristics:						
- HH head or spouse and is self-employed	-1.007***	-0.610***	-0.0149	1.658***	-0.131	0.871***
- Experience food problems	0.0417	0.0325	-0.00381	-0.0716		
- School drop due to lack of ways	0.280	0.125	0.0647	-0.532		
- Mining revenue	0.00309	0.00208	0.00222**	-0.000427	0.000628	
- Average age of population	-0.00689	-0.00428*	-0.00209	0.00612		
- Log average expenditure					0.0328	-0.0159
- Dropped out of school					0.797***	-0.360
- Economic situation of the HH						0.146***
- Proportion of women						0.755**
- Log of population of the department						-0.0269
Constant	0.983***	0.520***	0.492***	11.79***	-0.118	0.204
Observations	392	392	392	392	392	392

Source: Produced by the authors using the 2003-2009 data. Robust estimations clustered at the department level.

* p<0.10, ** p<0.05, *** p<0.010

Table 13: Loayza et *al.* model estimations with provincial dummies

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Producing department	-0.108***	-0.0480**	0.00631	0.142***	-0.0883**	0.0889**
Headcount ratio in 2003	-0.101	-0.0819	-0.0579	0.106		
Literacy rate in 2003	-0.208	-0.0774	0.180***	0.440**		
Proportion of areas with plots	-0.258***	-0.127***	0.104***	0.608***		
Log of area	-0.00235	-0.00854	0.0277***	0.0484		
Log of rural population	-0.000615	0.000577	0.00181	-0.00105	-0.0142**	0.0169**
Producing province					-0.0678*	0.0691*
HH head or spouse is self-employed					-0.124	0.280
Economic situation of the HH					0.0185	0.0998
Proportion of women					0.621	0.589
Log average expenditure					0.172***	-0.121**
Constant	0.707***	0.286***	0.0884	11.40***	-1.937***	1.496**
Observations	201	201	201	201	201	201
R^2	0.475	0.475	0.417	0.583	0.142	0.110

Source: Produced by the authors using the 2003-2009 data. The last two columns do not include the provincial dummies.
* p<0.10, ** p<0.05, *** p<0.010

Table 14: Loayza et *al.* model estimations with less covariates

	Headcount	Poverty gap	Gini	Expenditure	Schooling	Child labor
Producing department	-0.0766**	-0.0339*	0.0228*	0.140**	-0.0598	0.0615
Headcount ratio in 2003	0.225***	0.0754*	-0.0932**	-0.449***		
Literacy rate in 2003	-0.0889	-0.0501	0.0943**	0.196		
Proportion of areas with plots	-0.249***	-0.123***	0.0787***	0.555***		
Producing province					-0.0684**	0.0644**
HH head or spouse is self-employed					-0.119	0.0882
Economic situation of the HH					-0.0406	0.129**
Proportion of women					0.404	0.372
Log average expenditure					0.152***	-0.109***
Constant	0.453***	0.161***	0.326***	12.05***	-1.708***	1.666***
Observations	201	201	201	201	284	284
R^2	0.147	0.126	0.158	0.265	0.097	0.067

Source: Produced by the authors using the 2003-2009 data. The last two columns do not include the provincial dummies.

* p<0.10, ** p<0.05, *** p<0.010

E Figures

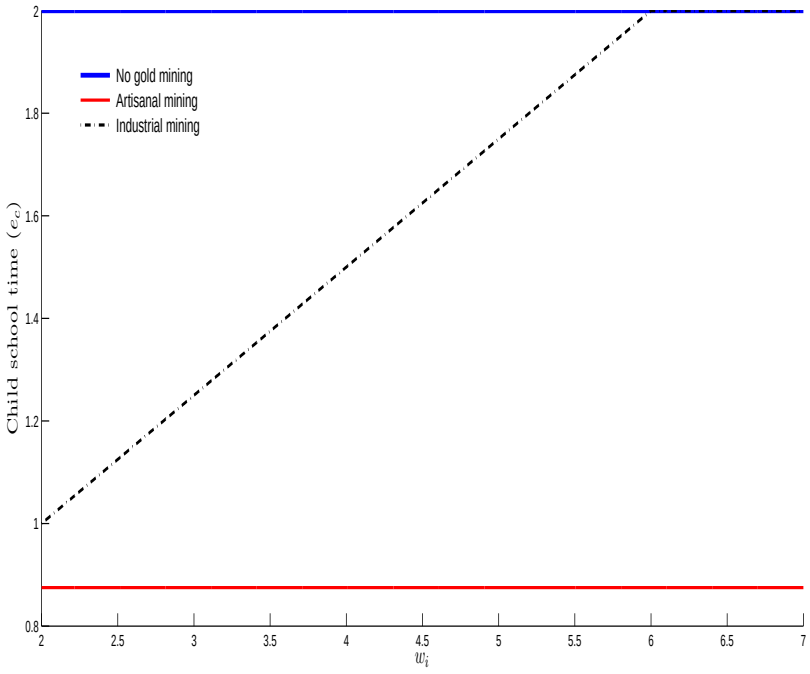

Figure 4: Child schooling time as a function of industrial wage. We set $A = 1$, $\alpha = \beta = 0.5$, $t_c = 2$, $t_a = 1$, $w_c = 1$, $w_x = 1.5$, $p_0 = p_1 = 1$.

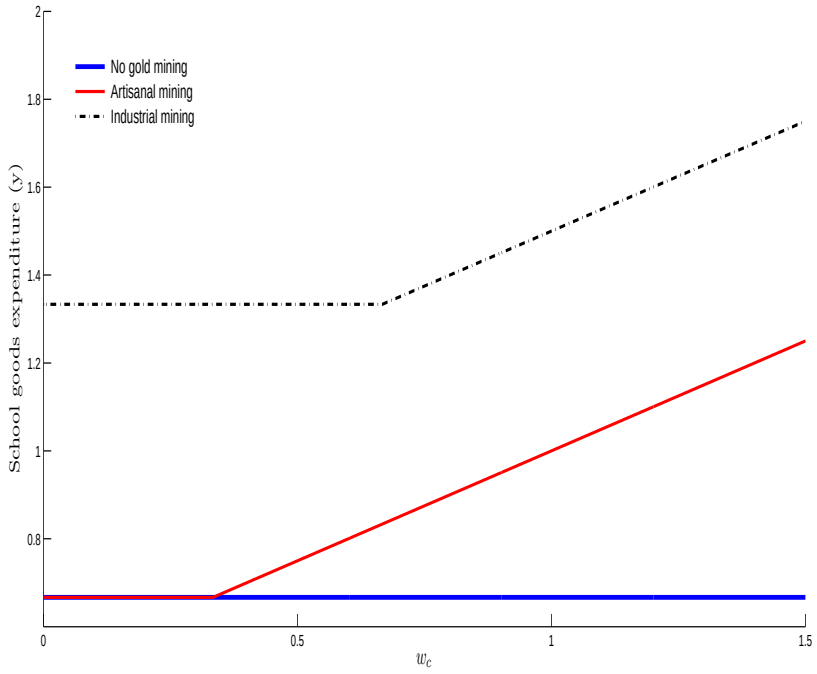

Figure 5: School goods expenditure as function of child wage. We set $A = 1$, $\alpha = \beta = 0.5$, $t_c = 2$, $t_a = 1$, $w_i = 4$, $w_x = 2$, $p_0 = p_1 = 1$.

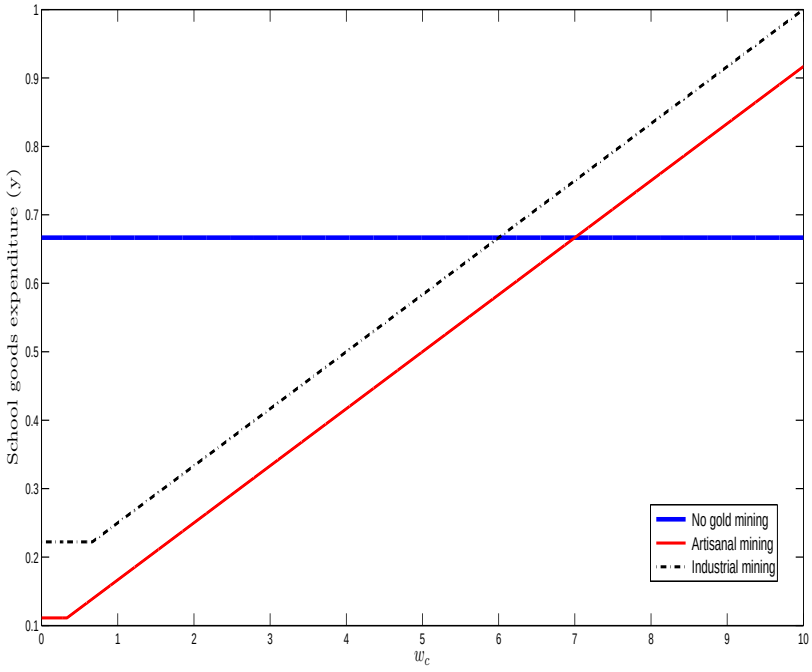

Figure 6: School goods expenditure as function of child wage. We set $A = 1$, $\alpha = \beta = 0.5$, $t_c = 2$, $t_a = 1$, $w_i = 4$, $w_x = 2$, $p_0 = 1$, $p_1 = 6$.