When Coal Leaves Town: Can Local Governments Help?

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Abstract

This article provides new evidence on the impacts of coal mine closures on local labor markets and the role of mitigation policies. Using data on 285 Polish municipalities from 1995 to 2016, the results show that the employment rates of men falls by 3 and 8 percentage points in the short- and long-term, respectively, in municipalities that experience a mine closure. *Mining communes* –having greater privileges over revenue collection– receive more intergovernmental transfers and increase their expenditures on family benefits during a coal mine closure. These policies are associated with smaller job losses in the short-term but with a sluggish recovery in the long-term. Given the low levels of labor mobility and wage flexibility that characterize the Polish labor market, the findings are consistent with local fiscal policies cushioning the negative impacts of coal mine closures on the demand for local goods and services in the short-term. In contrast, they may contribute to raise the reservation wage and thereby to slow down employment growth in the long-term.

Keywords: coal, local government, employment

JEL Codes: J23, H72, Q52

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1 Introduction

Since 2000, more than one million coal mining jobs were destroyed worldwide.[1] Despite these trends, the sector continues to be a key employer of low-skilled workers in coal-producing countries, accounting for more than five million jobs. As a result, the coal sector still is the main source of income for large numbers of families and communities in these countries not only directly but also indirectly given coal's backward and forward linkages to other industries. In Europe, for instance, the number of jobs that depend indirectly on coal activities is about the same as the total number of coal jobs (Alves Dias et al. 2018).

While developed countries made progress in the transition toward cleaner forms of energy, the rest of the world has not yet taken significant steps in this direction. In fact, more than ninety percent of coal mining jobs are located in the developing world, with China, India, and Indonesia leading the group. Several forces of change, including new technologies and policies of fostering cleaner forms of energy, appear to threaten coal workers in developing countries with the risk of massive layoffs.[2]

The impacts of coal mine closures on the labor markets of rich economies have been well documented (see, for example, Black et al. (2005*a*) and Black et al. (2005*b*)), but little is known about their impacts on middle-income countries with less flexible labor markets and lower geographic mobility. Moreover, empirical evidence on the role of local governments' policies to mitigate the shock is limited. This article helps to fill this gap in the literature by investigating the labor market adjustment to the secular decline of Poland's coal industry since the 1990s – a period when the country transitioned from a lower-middle-income to a high-income economy[3] – and by examining the role of local governments in facilitating the adjustment.

Poland is an interesting case to investigate this question for several reasons. First, because

[1] See Table 1

[2] "China expects to lay off 1.8 million workers in coal, steel sectors," Reuters, February 28, 2016 (https://www.reuters.com/article/us-china-economy-employment-idUSKCN0W205X)

[3] Based on the World Bank's historical income classification (http://databank.worldbank.org/data/download/site-content/OGHIST.xls)

the size of its coal industry was (and still is) significant, both in relative and absolute terms (Sokolowski et al. 2021). In the early 1990s, coal mines provided more than 400,000 jobs in Poland (Szpor & Ziółkowska 2018). In 2000, mining jobs represented almost twenty percent of male employment in Polish coal regions.[4] In 1995, the value added of the sector was equivalent to 15 percent of the Silesian region's value added (the main coal province in Poland).[5] These figures experienced dramatic changes over the following decades. By around 2014, coal mining employment and value added, while still significant, represented only about 14 and 5 percent of the Silesian region, respectively. Second, coal deposits and mines have not been confined to only one region, a feature that facilitates the estimation strategy of this paper by allowing for enough geographic variation (see Figure 2). Third, during this period, Poland transitioned from a centrally planned system to a market economy. This is important because some of the main coal countries still depend heavily on the government for the allocation of economic resources, particularly in the coal sector. Finally, this article also exploits the fact that coal towns in Poland have privileges regarding the collection and use of fiscal revenues. It provides new empirical evidence on local governments' policies to mitigate the impacts of coal mine closures, which is limited.

I use data for 285 municipalities (or *Gminas*) to estimate the impacts of coal mine closures on employment and total population. I find that these impacts are immediate and long-lasting. Municipalities that experienced at least one coal mine closure suffered a reduction in the employment rates of men of about 3 percentage points. When considering the impacts over the 21-year period between 1995 and 2016, municipalities that experienced a coal mine closure suffered a permanent reduction in the employment rate of men of about 8 percentage points. Female employment rates were not affected. Average salaries and total population did not change in response to a coal mine closure.

I also examine the size of the impacts spilling over into non-coal sectors by using data from the Polish firm registry from 1995 to 2009 and a balanced panel of firms from 2002 to

[4]Source: my own estimates based on microdata from the Labor Force Survey for 2000
[5]Source: Regional Accounts, Central Statistical Office of Poland

2009. The impacts on firm entry and exit were weak and limited to businesses in Agriculture, Manufacturing, and Hotels and Restaurants. The impacts were stronger on firm-level employment and average wage. Non-coal private sector firms reduced employment by almost 3 percentage points in response to a coal mine closure. They also adjusted by changing their staff composition. In particular, layoffs seem to have been focused on low-wage workers.

Mining communes that experienced a coal mine closure were more likely to increase their fiscal effort by raising their own revenues and receiving additional intergovernmental transfers. These additional fiscal revenues were partly channeled to larger family benefits per capita. Investments, grants, and wage expenditures did not significantly changed during the shock. In the short-term, the increased intergovernmental transfers and family expenditures mitigated the impacts of coal mine closures on employment. Among municipalities that experienced a coal mine closure, those that raised family benefits per capita by 10 percent, experienced smaller declines in male employment rates by about 0.8 percentage points. Firms producing non-tradable goods and services were less likely to destroy jobs in municipalities that raised their family benefits. In the long-term, however, I found opposite results. Job creation in the non-tradable sector was weaker when affected municipalities increased their family benefits expenditures more. A simple model of labor demand and supply without labor mobility and wage flexibility suggests two competing forces driving these results. On the one hand, additional government expenditures can partially offset the decline in the demand for local goods and services caused by the coal mine closure. On the other hand, the increase in family benefits can push up the reservation wage and reduce labor supply. While the first channel seems to dominate in the short-term, the second one seems to become more important in the long-term.

The estimated impacts are likely to reflect causality. While the location and timing of coal mine closures are not necessarily exogenous ex-ante, I show evidence that the parallel trends assumption needed for identification in differences-in-differences models is likely satisfied. In particular, municipalities that experienced a coal mine closure exhibited similar trends in

employment and fiscal outcomes before the closure.

This article contributes to the literature on the impacts of changes in the coal sector on local communities. This literature is relatively scarce and focuses on the United States. Black et al. (2005*b*) focus on four coal states from the United States (Kentucky, Ohio, Pennsylvania and West Virginia) and compare the economic performance of counties with coal deposits against that of counties without coal deposits. They find modest spill-over impacts on sectors with locally traded goods, and no impacts on sectors with nationally traded goods. Black et al. (2005*a*) show that changes in the coal sector in the United States had significant impacts on the local demand for education by shifting its wage returns. Black et al. (2002) find that the coal boom and bust had large effects on welfare expenditures and enrollment in disability programs in the United States, as well as large changes in family structure. Matheis (2016) examines the long-run effects of coal mine activity from 1870 to 1970 in the United States, which tend to be positive in the short run and negative in the long-run. Glaeser et al. (2015) find that distance to coal deposits is correlated with entrepreneurial activity. There is also empirical evidence for the United Kingdom. For instance, Aragón et al. (2018) examine the decline of the coal sector and find negative impacts on population size and wages, which are different for men and women.[6] To my knowledge, there is no evidence on the impacts of coal mine closures on the local labor markets of low- and middle-income countries.[7] A second contribution of this article is providing new evidence on the role of local governments in facilitating the labor market adjustment after a coal mine closure, which is scarce and mostly anecdotal.[8]

The rest of this article is structured as follows. Section 2 provides a brief history of the

[6]See also Beatty & Fothergill (1996)

[7]Related empirical evidence for developing economies tends to focus on the impacts of existing mines (and not necessarily coal mines), rather than their closure. In addition, they do not study the links with the secular and global transition out of coal. For instance, von der Goltz & Barnwal (2018) find that proximity to mines in 44 developing countries is linked to higher household wealth but poorer health outcomes. Other notable papers in this area include Aragón & Rud (2013), who find large positive effects on real incomes of a gold mine in Peru, and Kotsadam & Tolonen (2016), who find strong effects of mine openings on labor demand in Africa.

[8]See, for example, Krawchenko & Gordon (2021), Cunningham & Schmillen (2021), Harrahill & Douglas (2019), Mayer (2018)

re-structuring of the coal sector in Poland. Section 3 outlines the econometric model, and section 4 describes the data. Section 5 describes the findings, and section 6 concludes.

2 The Polish Coal Sector

The Polish coal sector underwent a major transformation, strongly linked to Poland's transition to a market economy. Szpor & Ziółkowska (2018) provide a detailed description of these developments. They show that from 1990 to 2016, the number of coal miners decreased from about 400,000 to less than 100,000. Accordingly, the number of hard coal mines declined from 70 to 30. Production fell, although to a lesser extent, reflecting an increase in the productivity of the sector. The first wave of reforms was aimed at increasing the efficiency of the sector. The second, which started in the 2000s, was also driven by a shift toward renewable forms of energy, a change enforced by the European Union climate and energy policies. Figure 1 shows the dramatic decline in coal production, employment, and number of active coal mines during this period.

Hard coal deposits and coal mine closures are not evenly distributed across Poland (see Figure 2). They are heavily concentrated in the Upper Silesian region (highlighted region in the middle of Figure 2 (b)). Hard coal deposits are also located in the *Lower Silesian* Province (Western region in Figure 2 (b)) and the *Lublin* Province (Eastern region in Figure 2 (b)). Currently, active hard coal mines exist only in the Upper Silesian and Lublin regions (Alves Dias et al. 2018).

Municipalities near hard coal deposits developed a strong dependence on this natural resource for job creation and economic growth. In the Silesian province, there were more than ninety thousand coal mine jobs in 2014 (Szpor & Ziółkowska 2018), representing about 5 percent of the total number of formal jobs that year in the region. While the dependence on coal significantly declined, compliance with international climate agreements will likely require further adjustments (Berrah 2018).

While brown coal (lignite) mining is also important in Poland, this paper does not consider it because the sector is considerably smaller in terms of both production and direct and indirect jobs when compared to the hard coal sector. Lignite mining jobs represent only 10 percent of the number of hard coal mining jobs.

2.1 The Mining Law of 1998

The Mining Law of 1998 introduced the definition of *mining commune*, which is a commune that had an active hard coal mine in 1999 or later. There were 73 *mining communes* (Szpor & Ziółkowska 2018), all of which enjoyed several privileges when compared to other communes.

Mining communes were allowed to partner with existing coal companies to create jobs outside the coal sector. The law also obliged liquidating mining companies to cooperate with local governments regarding the transfer of their superfluous assets to the latter. In addition, *mining communes* received a larger amount of the personal income tax when compared to other communes.[9] They also had access to preferential loans from the national government to foster economic activity in the region. The loan could amount to 75-80 percent of the planned investment. While there is some suggestive evidence that these privileges were not actually used by mining communes (Szpor & Ziółkowska 2018), I show below that municipalities that experienced a coal mine closure seem to have taken advantage of the additional fiscal revenues allowed by the program.

3 Econometric Model

To estimate the impact of a decline in the coal industry on municipal outcomes, I use the following model:

$$Y_{r,t} = \alpha + \beta closure_{r,t} + \Theta X_{r,t} + \mu_t + \mu_r + \epsilon_{r,t} \tag{1}$$

[9]In Poland the income from personal income tax is divided between communes and the national budget (Szpor & Ziółkowska 2018)

where β captures the impact of coal mine closures on outcome Y. *closure* is a variable indicating that municipality r experienced a coal mine closure in time t. X is a vector of control variables, and μ_t and μ_r are time and municipal fixed effects. Thereby, the coefficient β measures the change in Y in municipalities that experienced near coal mine closures relative to other regions.

The estimated impacts of coal mine closures may be biased. For instance, if private-sector actors anticipate a coal mine closure, they may decide to shut down businesses or to move to another location ahead of time. If this were the case, the estimated impacts would be biased downward. On the other hand, if a decision to close a coal mine is based on the local level of economic activity, then the estimates would be biased upward, as they would be attributed a decline in the dependent variable that is not related to mine closures.

While the decision to shut down hard coal mines could have been driven by omitted variables, I show that municipalities that experienced a coal mine closure exhibited trends in employment and other outcomes similar to those of nearby municipalities that did not experienced coal mine closures. In other words, this evidence supports the paralell trends assumption needed for identification of differences-in-differences model holds.

4 Data

I merge several datasets on employment, demography, firm registries and geological information on the location of hard coal deposits in Poland.

Hard coal mines and deposits: I obtained the list of coal mines and coal mine closures from Kasztelewicz et al. (2015). As seen in Figure 2 (b), there have been three broad coal regions in Poland: Lower Silesia (highlighted area in the West), Upper Silesia (highlighted area in the South), and Lublin (highlighted area in the East). Only the latter two still have operating hard coal mines. Only Lower and Upper Silesia experienced coal mine closures since the 1990s (Figure 2 (c)). Unfortunately, data on total employment and production

per mine are not available. Thereby, I use a binary variable for mine closures as the main independent variable instead of changes in coal employment or production at the mine level.

I also use the exact location of the hard coal deposits from the National Research Institute of the Polish Geological Institute.[10] As seen in Figure 2 (a), hard coal deposits are not concentrated in just one area and stretch across several municipalities.

Labor data: Data on employment and population from 1995 to 2016 by municipality come from the Central Statistical Office of Poland. Total employment excludes firms with five employees or fewer (for the years 1995-1998), and with nine employees or fewer (from 2000 to 2016). I define the employment rate as the ratio between this employment figure and the working age population (men aged 15-64, and women aged 15-59).

Average wages at the county (*powiat*) level come from the Central Statistical Office of Poland, and the sources are the Social Security records. They cannot be disaggregated by gender.

Firm data: The number of firms by sector of economic activity and municipality for the 1995 to 2009 period comes from the REGON registry. I exclude state-owned firms, the public sector and mining.

I use a balanced panel of firms from ORBIS to obtain measures of firm entry and growth, from 2002 to 2009. Changes in coverage over time makes it impossible to create a longer panel. These data come from administrative sources and their representativeness is not clear ex-ante (Kalemli-Ozcan et al. 2015). The total number of jobs in this selection of firms represent 26 percent of the total number of jobs from official records from 2002 to 2009, which is non-negligible and it is stable over the 2002-2009 period.

Local government revenues and expenditures: They cover each municipality from 1995 to 2016. The source is the Statistical Office. Revenues include intergovernmental transfers and own revenues, both of which add up to total revenues. Total expenditures include public investments, grants, family benefits, wages, and purchases. The series for wages and

[10] https://www.pgi.gov.pl/en/

purchases begin in 2008, thereby they were not included in the analysis. Family benefits are paid to families or individuals with a dependent child whose income per capita does not exceed a certain threshold. In 2001, the amount of the monthly benefit for a family with two children represented about 3.6 percent of the average monthly gross remuneration at the national level and 9.7 percent of the monthly minimum wage [11]. Grants are targeted subsidies received from the central government for an assigned task, over which the municipality has no discretion (Kotarba & Kolomycew 2014).

5 Results

Figure 3 shows the change in the employment rate by distance to the coal mine closure. It shows the 95% confidence intervals using robust standard errors. The effects of coal mine closures are highly concentrated around the localization of the mine. Thereby, the rest of this section defines the treatment group as one that includes those municipalities that experienced a coal mine closure within their boundaries. Accordingly, the control group includes municipalities in a 50-kilometer radius of an active coal mine in 1995 (blue areas in Figure 2 (b), excluding the Lublin basin in the East).

Table 2 shows the impacts of coal mine closures on employment, wages and population size. I introduce *closure* lagged by one period, since local labor markets seem to respond with a delay (see Figure 4 (a)). Columns (2), (5) and (8) control for non-linear trends across *Voivodeship* (Province), while columns (3), (6) and (9) include lagged value added per worker and lagged average wages to control for other unobserved factors such as productivity levels. My preferred estimates are the most parsimonious specifications in columns (1), (4) and (7). The decline in the employment rate as a result of a coal mine closure is statistically significant. A coal mine closure reduces the share of employed people in the municipality by almost 2.1 percentage points. The impacts are statistically significant only for men. According to columns (4) and (7), a coal mine closure reduces male employment rates by 3.1

[11] Source: http://www.oecd.org/social/benefits-and-wages/; http://www.oecd.org/els/soc/34007276.pdf.

percentage points, and has no significant impact on female employment. Since these data sources do not allow for separation of employment rate by sector, these figures include the direct job losses from the coal sector, as well as any spill-over effects into the rest of the local economy.

Wages do not change significantly as a result of a coal mine closure. This may be explained by the fact that the source of the wage data includes only the formal sector, thereby any wage adjustments in the more flexible informal sector would not be captured. The finding is consistent with evidence showing that while wages are relatively flexible in Poland (Brzoza-Brzezina & Socha (2007) and Strzelecki & Wyszynski (2016)), the Upper Silesian region –where most of the hard coal mines are– is characterized by higher wage rigidity (Puhani (2000)).

The size of the working age population does not change as a result of a coal mine closure in the municipality. This result holds when examining the impacts on male and female populations separately. This finding is consistent with the fact that geographic mobility in Poland is very low, even when compared to other European countries. While in the early 2000s 33.7 percent of the US population moved in the past 5 years, the corresponding figure for Poland was just slightly above 10 percent (Inchauste et al. 2018). The fact that relative wages and the size of the labor supply do not adjust in response to the shock may exacerbate the negative impacts of coal mine closures on the employment rate.

To attribute the change in employment rates to the mine closure, pre-existing trends across areas should be similar. Figure 4 shows some descriptive evidence supporting this hypothesis. In the time period before the first coal mine closure experienced by a municipality, the employment rate of men exhibited similar trends to that of municipalities in the control group. In this figure, the employment rate of the control group is a weighed average. In particular, I weight the non-mining municipalities to reflect the calendar year composition of mining municipalities each year before and after their first mine closure.[12] For example,

[12]I follow Mazzocco et al. (2014), who uses a similar approach to explore changes in labor supply between people who transition in an out of the labor market and those who do not change status

if 10 percent of coal mine closures took place in 2000 and 90 percent took place in 2002,then the dashed line gives more weight (90 percent) to municipalities in the control group in the year 2002 (which would correspond to time t=0 in the figure). Accordingly, one year after the closure (t=1), municipalities in the control group in the year 2003 would receive a 90 percent weight. The chart indicates that the employment rate of men in the treatment group falls by more than twenty percent in two years after the coal mine closure, while that of the control group falls by 5 percent or less in the same timeframe.

Figure 5 (a) confirms the validity of this assumption using an event-study regression framework. It plots the difference in employment rates across areas that did and did not experience a coal mine closure over time. The coefficients associated with lead effects can also be interpreted as a placebo test. Three years before a coal mine closure, the employment rate tended to be higher in areas that eventually experienced a coal mine closure than among municipalities that did not experience one. The difference becomes statistically insignificant two and one year before the closure. Municipalities that experienced a coal mine closure see a disproportionate reduction in employment one year after the closure. In other words, the reduction in employment observed in municipalities affected by a coal mine closure is likely to be explained by the latter and not by pre-existing trends.

5.1 Spill-over impacts

The estimated employment impacts are driven not only by the direct impacts of layoffs in the coal sector but also by spill-over effects. I analyze the extent of spill-over impacts using three measures: changes in the number of non-mining private sector firms, normalized by the total population in 1995; and employment and wage bill per worker growth within a balanced panel of non-mining private sector firms between 2002 and 2009. Given the lack of impacts of coal mine closures on wage levels, changes in the latter are more likely to be driven by changes in the composition of employment.

The total number of non-mining firms was not significantly affected by coal mine closures

(Table 3, column (1)). Only the number of firms in Agriculture, Manufacturing, and Hotels and Restaurants declined in response to the shock, but only marginally. The number of manufacturing firms per inhabitant declines by approximately 0.03 percent when a coal mine closes. The impacts on the number of firms in Agriculture, and Hotels and Restaurants, are even lower.

The spill-over impacts are statistically significant on a balanced panel of non-mining private sector firms. Those in municipalities that experienced a coal mine closure had employment levels 2.4 percent lower than those in other municipalities (Table 4). The results are also reported for firms producing locally tradable and non-tradable goods and services separately. The former includes Agriculture and Manufacturing, while the latter includes the remaining sectors. In contrast to evidence for the US (Black et al. 2002), the impacts across tradable and non-tradable sectors are similar. The wage bill per worker in non-mining private sector firms tended to increase more among those from municipalities that suffered a coal mine closure than among those from other locations. This may reflect the change in firms' employment composition mentioned above. Given that the level of wages is rigid, the rise in the wage bill per worker likely reflects an increased intensity in high-wage or high-skill employment. These impacts seem greater among firms in the non-tradable sector.

5.2 Impacts on local government finances

As described in section 2, *mining communes* had more discretion than other municipalities over their finances. The evidence suggests that they were in fact more likely to increase their revenues –both from their own fiscal effort and intergovernmental transfers– when they experienced a coal mine closure. As seen in Table 5, their own fiscal revenues and intergovernmental transfers –both in per capita terms– increased by about 4.6 and 5.6 percent when they experienced a coal mine closure. The increased revenues were more likely to be spent on family benefits than on public investments or grants. In fact, total expenditures per capita did not change as a result of a coal mine closure when compared to municipalities

that did not experience one. Family benefits per capita increased by about 5.4 percentage points during a coal mine closure.

As seen in Figure 5, the increase in own revenues, intergovernmental transfers and family benefits had more of a transitory nature. The trends in these variables across areas that did and did not experience a coal mine closure were very similar before the closure, and became similar again after the spike experienced during the closure. This is confirmed by the coefficients in Figures 5 (c) and (d) being statistically different from zero only during the year that the municipality experienced a coal mine closure.

Table 5 also reports the results without controlling for municipality fixed effects, to estimate whether *mining communes*' public finances were different from those of other municipalities even when they did not experience a mine closure. It shows that *mining communes* had higher levels of own revenue, total revenue and expenditure per capita than other municipalities. The differences are large; a *mining commune* had levels of own revenue per capita 19.4 percent higher than other municipalities on average between 1995 and 2016. The results also confirm that the higher levels of intergovernmental transfers and family benefits per capita of *mining communes* are explained by the short-term effects of coal mine closures.

The impacts of local governments' finances on the labor market during a coal mine closure were statistically significant but small. I examine the role of intergovernmental transfers and family benefits, since these are the two categories that experienced a significant increase during a coal mine closure. Table 6 shows the interaction effects of coal mine closures with local government's finances on the municipality's employment rate, and firms' employment and wage bill per worker. The models control for different trends across mining and non-mining communes to address the fact that unobserved factors may explain their different revenue and spending decisions. The results show that municipalities that received additional intergovernmental transfers and raised expenditures in family benefits during a coal mine closure, experienced milder negative impacts on the employment rate.[13] Among

[13]While the coefficient associated with *closure* seems large, this is because the average level of intergovernmental transfers and family benefits is also high among mining communes. For example, average family

municipalities that experienced a coal mine closure, those that raised family benefits per capita by 10 percent, experienced smaller declines in the employment rate by about 0.8 percentage points.[14] A 10-percent increase in family benefits per capita is non-trivial. In 2016, that was approximately 123 zloty or 31 US dollars, which was equivalent to 0.25 percent of per capita GDP and 0.36 percent of average annual salaries in *mining communes*. The mitigating effect of government finances on the labor market seems to be driven by lower job destruction among non-mining private firms in the non-tradable sector (Table 6 column (3)). A 10-percent increase in family benefits increases employment at the firm level by about 2 percent among municipalities that experienced a coal mine closure. The impacts on the wage bill per worker are rather similar across different levels of family benefits

5.3 Long-term impacts of coal mine closures

This section explores the long-term impacts of coal mine closures over the 21-year period between 1995 and 2016. The results should be interpreted with caution since the number of coal mine closures is not necessarily exogenous over such an extended timeframe, and it is not possible to show that the assumption of parallel trends holds, due to data constraints.

The impacts of coal mine closures seem permanent for men in affected municipalities. Those that experienced one mine closure between 1995 and 2016 have employment rates about 8 percentage points lower than men living in municipalities that did not experience a closure. The impacts are not statistically significant for women.

Unlike the findings in Subsection 5.2, the long-term negative impacts are larger among municipalities that had higher levels of expenditures per capita on family benefits or received additional intergovernmental transfers. Municipalities that received additional intergovernmental transfers of about 10 percent, experienced an additional decline in male employment

benefits during a coal mine closure were 571 log points, which implies that for the average municipality experiencing a coal mine closure the total impact on the employment rate of men would be 4.71 percentage points ($-49.11 \times closure + 0.0812 \times 571 \times closure + 0.00269 \times 571 = 4.71$). This figure is closer to the point estimates reported in columns (4) to (6) of Table 2.

[14]Since the specification is a lin-log model and family benefits are in log points, the impact of a 10 percent increase in family benefits per capita on the employment rate is equal to $\frac{\beta}{100} \times 100 \times 10$

rates of about 1.47 percentage points (column (1)). The corresponding coefficient for family benefits is also negative but not statistically significant. However, columns (2) and (3) suggest that an increase of 10 percent in family benefits per capita during this period reduced firm-level employment by about 4.2 percent, and by about 12 percent in the non-tradable sector. The positive coefficients associated with the number of mine closings in columns 2 through 4 likely reflect the hiring of displaced coal workers into the non-coal sector. The negative coefficients associated with the number of mine closings in columns 5 through 7 are consistent with this hypothesis, as they likely reflect a change in the composition of employment at the firm level toward unskilled workers. This shift was weaker among municipalities that increased their expenditures in family benefits per person.

6 Conclusion

This paper provides new evidence on the local impacts of coal mine closures in a country with very low levels of labor mobility and high wage rigidity. Using data on 285 Polish municipalities from 1995 to 2016 –a period of time when Poland transitioned from a lower middle-income to a high-income economy– it finds that coal mine closures had significant and long-lasting adverse impacts on the local employment rates of men.

These results are driven not only by the direct impact on coal employment, but also by reducing the net entry rate of firms in certain sectors such as Agriculture, Manufacturing, and Hotels and Restaurants. In addition, coal mine closures reduce firm-level employment growth, particularly the growth of low-wage jobs.

The article finds that local governments respond to mine closures by increasing revenue collection and expenditures in family benefits. The increase in local government expenditures toward family benefits partially offsets the negative impacts of coal mine closures on employment in the short-term. The opposite result is found in the long-term. A simple model of labor demand and supply suggests that while local government expenditures can

help sustain local employment in the short-term, they may increase reservation wages and lower job creation in the long-term.

The results indicate that local labor market shocks to unskilled labor are highly persistent, even during times of high economic growth, as was the case in Poland during this period. This suggests that frictions affecting geographic mobility are significant and may slow down the process of adjustment to coal mine closures in developing countries. Moreover, while the increase in local public expenditures seems to smooth the impact of the shock in the short-term, it seems to exacerbate it in the long-term.

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Tables

Table 1: Employment in coal mines around the world

	Number of Employees	%	Change (circa 2000 - circa 2015)
High income	349,846	6.4	-51,181
Developing	5,124,513	93.6	-1,163,340
Total	5,474,359	100.0	-1,214,521
East Asia & Pacific	4,510,670	82.4	-948,232
Europe & Central Asia	381,243	7.0	-263,653
Latin America & Caribbean	11,350	0.2	-1,139
Middle East & North Africa	10,063	0.2	-2,154
North America	168,219	3.1	657
South Asia	314,989	5.8	-
Sub-Saharan Africa	77,825	1.4	-
Total	5,474,359	100.0	-1,214,521

Source: UNIDO MINSTAT 2018, ISIC Revision 4. Country groupings by region and income level are based on the World Bank classifications. Data for India comes from Statista, and data for South Africa comes from https://www.mineralscouncil.org.za/industry-news/publications/facts-and-figures/send/17-facts-and-figures/442-facts-and-figures-2016

Table 2: Impact of coal mine closures on employment rates, wages and population size, 1995-2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Employment Rate								
	All			**Men**			**Women**		
Closure (t-1)	-2.056***	-2.054***	-1.674**	-3.166***	-3.136***	-2.048*	-0.862	-0.939*	-1.266*
	(0.717)	(0.755)	(0.778)	(1.131)	(1.178)	(1.111)	(0.532)	(0.534)	(0.767)
	Log(wages)								
	All								
Closure (t-1)	1.320	1.232	1.071*						
	(0.990)	(0.996)	(0.553)						
	Log(working age population)								
	All			**Men**			**Women**		
Closure (t-1)	0.726	0.687	0.918	0.478	0.368	0.830	0.978	1.019	1.000
	(1.095)	(1.073)	(0.998)	(1.027)	(0.994)	(0.972)	(1.188)	(1.179)	(1.035)
Municipality fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Lagged population (log)	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year x Voivodeship fixed effects	NO	YES	NO	NO	YES	NO	NO	YES	NO
Additional controls	NO	NO	YES	NO	NO	YES	NO	NO	YES
Observations	6,101	6,101	4,078	6,101	6,101	4,078	6,101	6,101	4,078

Note: Robust standard errors in parentheses, with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year. Employment rate is the ratio of total employment in firms with at least 9 employees to population aged 15 to 64 years, in percentage points. Wages are the average salaries from the social security administration at the county level, in log points. Population is the size of the working age population in the municipality, in log points. Columns(2), (5) and (8) control for non-linear trends across *Voivodeships* (Provinces). The municipality characteristics used as control variables in columns (3), (6) and (9) include log value added per worker (lagged) and log average wage (lagged). The wage regressions do not include log average wage as a control variable. The population regressions do not include lagged log population as a control variable.

Table 3: Impacts of coal mine closures on the number of non-mining private sector firms, 1995-2009

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	TOTAL	**Agriculture**	**Fishing**	**Manufacturing**	**Utilities**	**Construction**	**Wholesale and Retail**	**Hotels and restaurants**
Closure (t-1)	-0.0128	-0.0196**	-6.83e-05	-0.0343***	-0.000347	-0.0260	-0.0903	-0.0126**
	(0.00886)	(0.00757)	(0.000145)	(0.0103)	(0.000611)	(0.0210)	(0.0628)	(0.00505)
Observations	59,850	4,275	4,275	4,275	4,275	4,275	4,275	4,275

	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Transport and ICT	**Finance**	**Real estate**	**Public sector**	**Education**	**Health**	**Other services**
Closure (t-1)	-0.0159	0.00112	0.0225	-0.00699	0.00287	-0.00746	0.00742
	(0.00978)	(0.00947)	(0.0215)	(0.00467)	(0.00389)	(0.00705)	(0.0127)
Observations	4,275	4,275	4,275	4,275	4,275	4,275	4,275

Note: Robust standard errors in parentheses, with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995. The dependent variable is the number of non-mining private sector firms divided by the municipality's population in 1995, in log points. The regressions control for municipality and year fixed effects. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year.

Table 4: Impacts of coal mine closures on non-mining firm employment and wage bill, 2002-2009

	(1)	(2)	(3)	(4)	(5)	(6)
	Employment (log)			Wage bill per worker (log)		
	All sectors	Non-tradable sectors	Tradable sectors	All sectors	Non-tradable sectors	Tradable sectors
Closure (t-1)	-2.378*	-1.778	-2.335	14.63***	19.15***	11.43***
	(1.283)	(1.561)	(3.197)	(3.100)	(3.985)	(3.577)
Observations	14,472	8,192	5,448	8,257	4,971	2,811

Note: Robust standard errors clustered at the municipal level in parentheses, with *** p<0.01, ** p<0.05, * p<0.1. The sample includes non-coal private firms in 285 municipalities within a 50-kilometer radius of an active coal mine in 1995. The dependent variables are the number of employees and the wage bill per worker, both in log points. Controls include firm and year fixed effects, lagged population (log) and firm age. Estimated using yearly data from 2002 to 2009. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year.

Table 5: Impacts of coal mine closures on local government revenues and expenditures, 1995-2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	With Municipality fixed-effects						
	Own revenue	**Total revenue**	**Inter-gov transfers**	**Total Expenditure**	**Investment**	**Grants**	**Family Benefits**
Closure	4.579*	3.418	5.632**	2.608	9.671	6.853	5.471**
	(2.364)	(2.222)	(2.742)	(2.892)	(11.66)	(12.42)	(2.570)
Municipality fixed effects	YES	YES	YES	YES	YES	YES	YES
Lagged population (log)	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
	Without Municipality fixed effects						
	Own revenue	**Total revenue**	**Inter-gov transfers**	**Total Expenditure**	**Investment**	**Grants**	**Family Benefits**
Closure	-5.802	8.059**	22.23***	6.761	4.299	-17.61	16.56***
	(3.804)	(4.006)	(6.515)	(4.289)	(14.44)	(17.12)	(4.353)
Mining Commune =1	19.43***	10.83***	-1.409	10.31***	13.22***	2.811	-4.361***
	(1.571)	(1.154)	(1.708)	(1.172)	(3.590)	(3.367)	(1.190)
Municipality fixed effects	NO	NO	NO	NO	NO	NO	NO
Lagged population (log)	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
Year x Voivodeship fixed effects	YES	YES	YES	YES	YES	YES	YES
Observations	6,093	6,093	6,093	6,093	6,093	6,093	6,093

Note: Robust standard errors in parentheses, with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995. The dependent variables are different categories of municipal-level revenues and expenditures in per capita terms, and log points. Closure is a binary variable equal to 1 if the municipality experienced a coal mine closure the current year. The regressions include controls for municipality and year fixed effects (upper panel), lagged population levels (in logs), year fixed effects (upper panel) and non-linear trends across *Voivodeships* (Provinces) in the lower panel.

Table 6: Employment and wage impacts of coal mine closures: interaction with local government finance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Employment rate	Firm-level Employment (log points)			Wage bill per worker (log points)		
	Men	All	Non-tradable	Tradable	All	Non-tradable	Tradable
Closure (t-1)	-71.47**	6.846	-134.9***	201.4***	304.5	275.5	89.62
	(31.60)	(31.06)	(48.44)	(69.76)	(184.6)	(205.2)	(114.5)
Inter-gov transfers x Closure(t-1)	0.101**	-0.0146	0.189***	-0.294***	-0.479	-0.427	-0.124
	(0.0449)	(0.0456)	(0.0704)	(0.100)	(0.302)	(0.335)	(0.189)
Inter-gov transfers	0.00253	0.0158	0.0259	-0.0270	0.151	0.244*	-0.0218
	(0.00614)	(0.0573)	(0.0804)	(0.0859)	(0.118)	(0.131)	(0.196)
Observations	6,093	14,208	8,080	5,320	8,117	4,908	2,746
	Employment rate	Firm-level Employment (log points)			Wage bill per worker (log points)		
	Men	All	Non-tradable	Tradable	All	Non-tradable	Tradable
Closure (t-1)	-49.11***	-21.22	-143.9**	160.3**	-14.25	7.054	-38.18
	(18.01)	(45.86)	(64.05)	(79.25)	(87.37)	(84.73)	(89.19)
Family Benefits x Closure(t-1)	0.0812***	0.0295	0.231**	-0.269**	0.0380	0.0119	0.0734
	(0.0299)	(0.0769)	(0.106)	(0.131)	(0.125)	(0.122)	(0.130)
Family Benefits	-0.00269	-0.0830*	-0.173***	0.0191	-0.541***	-0.289	-1.060***
	(0.0119)	(0.0425)	(0.0632)	(0.0538)	(0.190)	(0.194)	(0.314)
Observations	6,093	14,208	8,080	5,320	8,117	4,908	2,746

Note: Robust standard errors (column 1) and standard errors clustered at the municipal level (columns 2 to 7), with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995. Data in column (1) is at the municipal level from 1995 to 2016, while data in columns (2) through (7) is a balanced panel of firms from 2002 to 2009. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year. Employment rate is the ratio of total employment in firms with at least 9 employees to population aged 15 to 64 years, in percentage points. Firm-level employment is the total number of employees per firm, and wage bill per worker is the total amount of wages paid divided by the number of employees in the firm. Intergovernmental transfers and family benefits at the local government level are in per capita terms, and in log points. All specifications control for different non-parametric trends across mining and non-mining communes.

Table 7: Long-term impacts of coal mine closures on employment rates, 1995-2016

	(1)	(2)	(3)	(4)	(5)	(6)
	Employment rate					
	All		**Men**		**Women**	
Number of coal mine closures, 1995-2016	-3.590	-2.752	-8.585**	-7.705**	-0.702	0.515
	(2.606)	(1.978)	(3.492)	(3.067)	(1.774)	(1.550)
Initial log population	YES	YES	YES	YES	YES	YES
County fixed effects	YES	YES	YES	YES	YES	YES
Initial municipality characteristics	NO	YES	NO	YES	NO	YES
Observations	285	285	285	285	285	285

Note: Robust standard errors in parentheses, with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995, and includes only the earliest (1995) and latest (2016) year in the sample. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year. Employment rate is the ratio of total employment in firms with at least 9 employees to population aged 15 to 64 years, in percentage points. It controls for Powiat (County) fixed effects and initial characteristics of the municipality to mitigate the role of omitted factors. The initial municipality characteristics in 1995 include total population (log), the number of phone lines per capita, the population share of college graduates, homeownership rate, value added per worker and average wages

Table 8: Long-term impacts of coal mine closures on employment rates and firms: Interation with local government finances

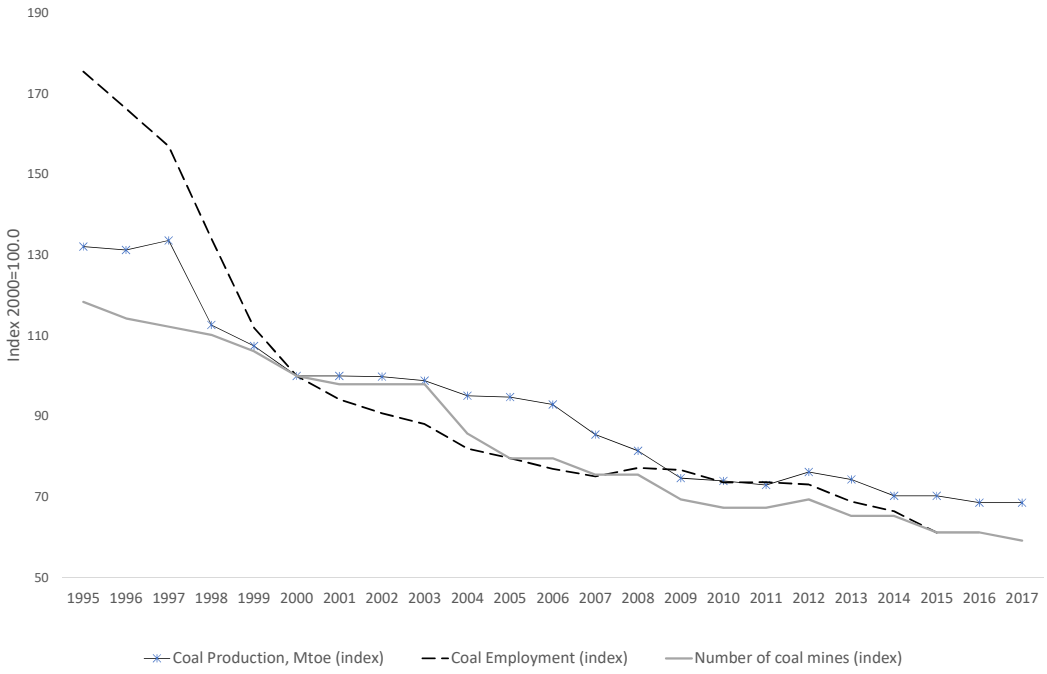
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Employment rate	Firm-level Employment (log)			Wage bill per worker (log)		
	Men	All	Non-tradable	Tradable	All	Non-tradable	Tradable
Number of coal mine closures, 1995-2016	11.31	4.311***	4.289	4.663*	-23.58***	1.272	-24.13***
	(11.20)	(1.547)	(4.836)	(2.490)	(6.866)	(7.157)	(7.178)
Inter-gov transfers x Number of closures	-0.147*	-0.00498	-0.116	0.191	0.201	-0.488	-0.225
	(0.0749)	(0.109)	(0.223)	(0.203)	(0.671)	(0.403)	(0.940)
Inter-gov transfers	0.00342	0.0867	-0.000579	0.0996	-0.419	-1.143**	0.221
	(0.00945)	(0.108)	(0.152)	(0.164)	(0.293)	(0.543)	(0.255)
Observations	285	1,776	665	1,010	1,147	385	699
	Employment rate	Firm-level Employment (log)			Wage bill per worker (log)		
	Men	All	Non-tradable	Tradable	All	Non-tradable	Tradable
Number of coal mine closures, 1995-2016	-1.057	19.39***	51.54***	-4.361	-62.44***	-3.318	-99.32***
	(18.48)	(6.921)	(18.47)	(6.623)	(15.74)	(36.15)	(21.01)
Family Benefits x number of closures	-0.0699	-0.418**	-1.273**	0.251	1.143***	0.160	1.962***
	(0.120)	(0.180)	(0.493)	(0.155)	(0.384)	(0.970)	(0.516)
Family Benefits	-0.0147	0.0519	0.233**	-0.0828	-0.0893	-0.260	0.0692
	(0.0547)	(0.0967)	(0.108)	(0.146)	(0.128)	(0.226)	(0.236)
Observations	285	1,776	665	1,010	1,147	385	699

Note: Robust standard errors (column 1) and standard errors clustered at the municipal level (columns 2 to 7), with *** p<0.01, ** p<0.05, * p<0.1. The sample includes 285 municipalities within a 50-kilometer radius of an active coal mine in 1995, and includes only the earliest and latest year in the sample. Data in column (1) is at the municipal level from 1995 to 2016, while data in columns (2) through (7) is a balanced panel of non-coal private firms from 2002 to 2009. Closure (t-1) is a binary variable equal to 1 if the municipality experienced a coal mine closure the previous year. Employment rate is the ratio of total employment in firms with at least 9 employees to population aged 15 to 64 years, in percentage points. Firm-level employment is the total number of employees per firm, and wage bill per worker is the total amount of wages paid divided by the

number of employees in the firm. Intergovernmental transfers and family benefits at the local government level are in per capita terms, and in log points. It controls for the municipality's population in 1995 across all columns, and for the initial age and total employment of the firm in columns (2) through (7).

Figures

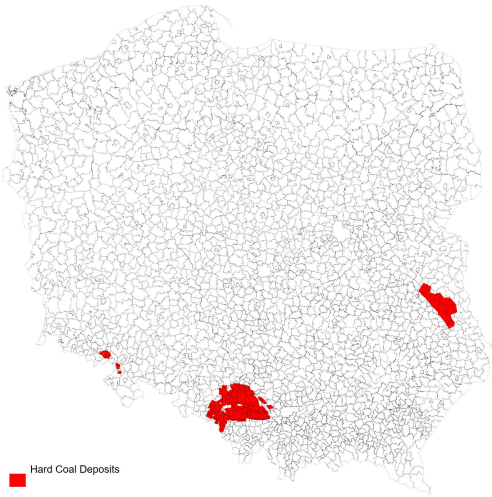
Figure 1: Trends in coal production, employment and mine closures



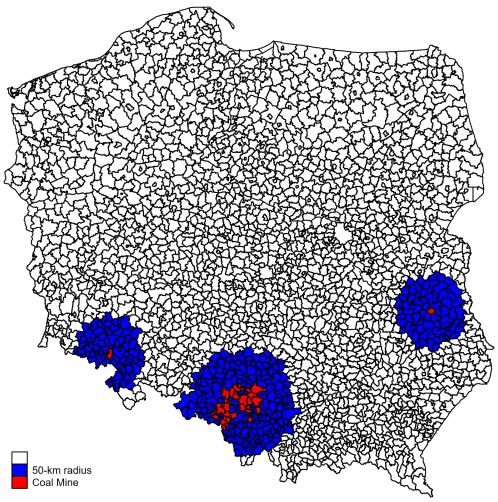
Note: Coal production and employment refers to hard coal.

Figure 2: Hard coal deposits, mines and closures by Municipalities (*Gminas*)

(a) Hard coal reserves



(b) Municipalities with a coal mine in 1995 (red) and surrounding areas



(c) Municipalities with a coal mine closing since 1995

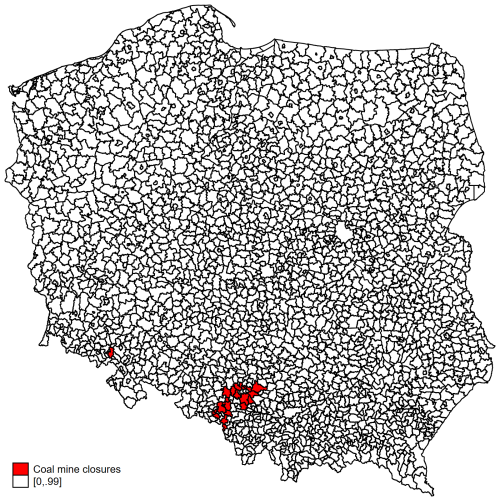
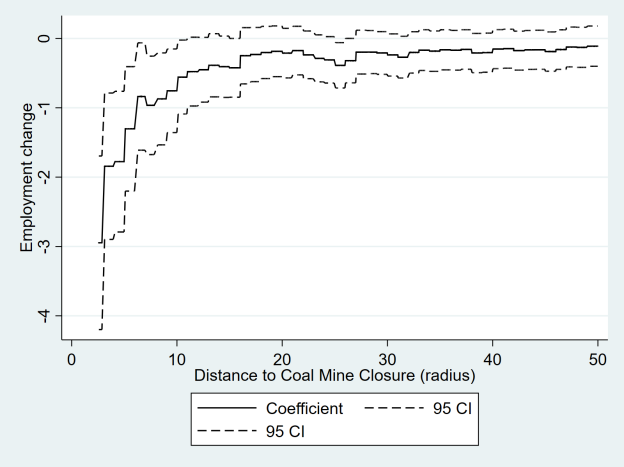


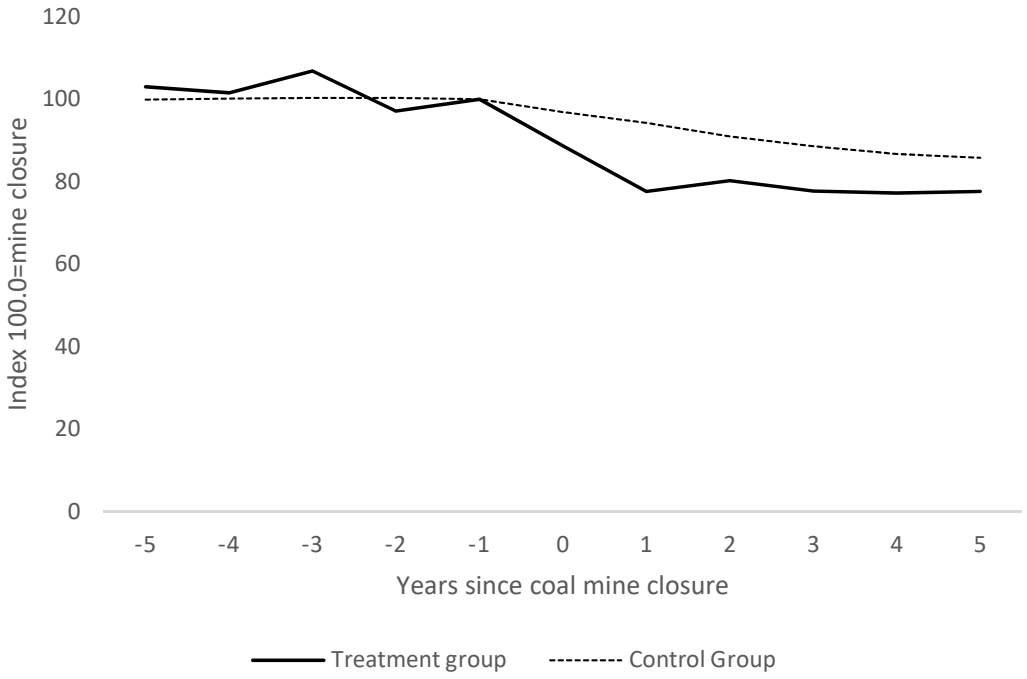
Figure 3: Coal mine closures and change in employment rates, by distance to nearest coal mine closure

(a) Employment rate, lead and lag effects



Note: the bold line shows the decline in the employment rate in municipalities within a radius (in kilometers) from the nearest coal mine closure, with respect to areas outside that radius. Estimated using 100 different OLS regressions, where the radius varies from 0 to a 100 kilometeres in each regression

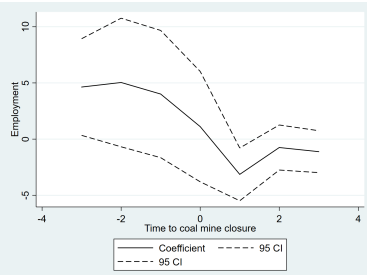
Figure 4: Male employment rates before and after a coal mine closure



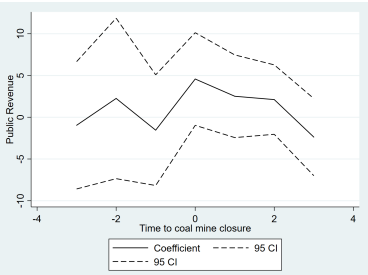
Note: The solid line is the employment rate of males in municipalities with a coal mine, before and after a coal mine closure (index equal to 100.0 one year before the coal mine closure. The dashed line is a weighted average of the male employment rates in the control group (areas within a 50 kilometer radius from the coal mine). For example, if 10 percent of coal mine closures took place in 2000 and 90 percent took place in 2002, then the dashed line gives more weight to municipalities in the control group in the year 2002. Accordingly, one year after the closure, municipalities in the control group in the year 2003 would receive a 90 percent weight.

Figure 5: Trends, lead and lag effects

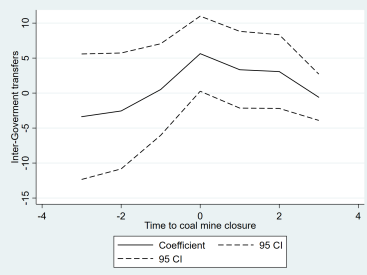
(a) Employment rate, lead and lag effects



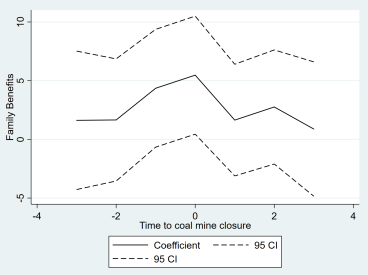
(b) Own revenue per capita, lead and lag effects



(c) Inter-gov transfers, lead and lag effects



(d) Family benefits, lead and lag effects



Note: each figure shows the OLS coefficient associated with a dummy variable indicating a coal mine closure, from 3 years before to three years after the closure. The employment rate is the ratio of total employment in firms with at least9 employees to population aged 15 to 64 years, in percentage points. The rest of the variables are own revenue per capita, inter-governmental transfers per capita and family benefits per capita, all in log points. Separate regressions were estimated for different lead and lag effects. Controls include municipality fixed effects, lagged log population, year fixed effects. Dashed lines show 95 percent confidence intervals with robust standard errors