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Agricultural Policy and Long-Run Development: Evidence from Mussolini's Battle for Grain

Mario F. Carillo

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University of Naples Federico II
University of Salerno
Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance
DEPARTMENT OF ECONOMICS – UNIVERSITY OF NAPLES
80126 NAPLES - ITALY
Tel. and fax +39 081 675372 – e-mail: csef@unina.it
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Agricultural Policy and Long-Run Development: Evidence from Mussolini's Battle for Grain

Mario F. Carillo*

Abstract
This paper explores the effect of agricultural policies on industrialization and economic development over the long run. I analyze the differential effect of the Battle for Grain, implemented by the Italian Fascist regime to achieve self-sufficiency in wheat production, on the development path across areas of Italy. Employing time variation, along with cross-sectional variation in the suitability of land for implementing the advanced wheat production technologies, I find that the policy had unintended positive effects on industrialization and economic prosperity which have persisted until the present day. Furthermore, I find that the positive effect of the Battle for Grain on human capital accumulation was instrumental in this process, suggesting that the complementarity between human capital and agricultural technology may be a critical mechanism through which agricultural productivity may enhance the development of non-agricultural sectors.

Keywords: Economic Growth; Agricultural Policy; Human Capital

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* Università di Napoli and CSEF. Address: Department of Economics and Statistics, University of Naples Federico II. Email: MarioFCarillo@gmail.com

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1 Introduction

A significant portion of the differences in living standards across regions is rooted in pre-industrial stages of development. The predominant role of the agricultural sector over this period has motivated the study of the effect of agricultural productivity on industrialization and the long-term evolution of the economy,[1] triggering a debate about the importance of agricultural productivity in the development process.[2] The inconclusive evidence about the relationship between agricultural productivity, industrialization, and long-run development has initiated a debate about the consequences of agricultural policies, which have been central in development strategies worldwide.

While agricultural policies may stimulate agricultural productivity and enhance income in the rural regions of the world, they may also cause market inefficiencies and rent-seeking and their consequences on industrial development are ambiguous.[3] The rise in agricultural productivity may foster human capital accumulation (Foster and Rosenzweig, 1996), and reallocate labor toward industry (Bustos et al., 2016), stimulating the development process. However, if the economy is sufficiently open, it may strengthen comparative advantage in the agricultural sector, harnessing industrialization and economic growth (Matsuyama, 1992; Galor and Mountford, 2008).[4] The empirical assessment of these mechanisms has proven challenging, mainly because of the difficulty in disentangling potential terms of trade effect of agricultural policy from its impact on technological adoption.

This paper sheds light on these issues exploring the *Battle for Grain* implemented by the Italian Fascist regime to achieve self-sufficiency in wheat through subsidies to more advanced wheat production technologies and tariffs on wheat imports. While the combination of interventions resulted in a major stimulus to technological progress in agriculture, the tariff significantly raised the price of wheat. I exploit the heterogeneous exposure to these effects across areas of Italy to *(i)* provide evidence of the effects of agricultural productivity policies on local industrialization and economic growth over the course of a century and *(ii)* empirically disentangle the effect of technological progress from the tariff-induced price increase and the associated rise in local agricultural income.

[1] See Boserup (1965) Diamond (1998), Olsson and Hibbs (2005), Ashraf and Galor (2011), Nunn and Qian (2011), Vollrath (2011).

[2] See Matsuyama (1992), Baumol (1967), Foster and Rosenzweig (2007),Gollin et al. (2002), Hornbeck and Keskin (2015), Bustos et al. (2016). I review the literature in more detail below.

[3] For the debate on the effects of policy interventions, see Yifu (2013).

[4] See also Field (1978); Mokyr (1976); Corden and Neary (1982); Krugman (1987).

The *Battle for Grain* (henceforth BG) was one of the major projects undertaken by Mussolini during his dictatorship. Implemented from 1925 to 1939, it was designed to move the country toward self-sufficiency in wheat production.[5] The intervention triggered a significant technical change in wheat production by stimulating new wheat production techniques[6] —including improved wheat seeds, machines, and fertilizers— which resembled a Green Revolution.[7] Furthermore, in order to give farmers incentives to adopt the new production techniques and intensify wheat production, significant tariffs in wheat were implemented.

To perform the empirical analysis, I digitized historical records for about 7000 municipalities by decade over the course of the 20th century and beyond. The sources include the 1929 Census of Agriculture, several population and industry censuses, and historical maps. I combine these data with highly disaggregated data on educational attainment and sector-specific employment across age groups within municipalities.

In the first step of the empirical analysis, I document that areas where wheat yield increased over the years of the BG experienced an acceleration in the process of industrialization and economic growth, which emerged after implementation and persisted long after its repeal, until today. Yet reverse causality may affect the estimates. For instance, faster population growth, and the associated higher demand for food, could raise the returns from adopting the more advanced wheat production techniques and increase wheat yield.

I examine the presence of a causal link using variation in the suitability of land for the more advanced wheat production technologies that were stimulated by the BG. I use these data to build a novel index measuring the potential exposure to the policy, which I interact with time indicators in a flexible specification. The identification strategy requires that there were no other factors correlated with the suitability of land for the specific wheat production technologies stimulated by the BG that affected economic development in this period. I perform robustness tests and placebo checks in support of this assumption.

To build the index, I use crop-specific potential yields from the Global Agro-

[5] In light of Mussolini's war plans, self-sufficiency in wheat production was instrumental to reducing dependency on foreign powers (Lyttelton, 2004).

[6] Studies on the link between agricultural technical change and agricultural productivity include Kantor and Whalley (2014); Emerick et al. (2016).

[7] The Regime financially supported a scientist, Nazareno Strampelli (1866 - 1942), who was the first to use Mendel's laws to create high-yielding varieties of wheat that were eventually adopted in several other countries such as China, Argentina, and Mexico. Recently, Strampelli was referred to as "the prophet of the Green Revolution" (Salvi et al., 2013).

Ecological Zones (GAEZ) methodology developed by the Food and Agriculture Organization (FAO). These measures of potential yields are exogenous as they are determined by geographic conditions and not by actual yields. The database provides potential wheat yield under traditional and more modern techniques — improved wheat varieties, machines, and fertilizers — which are precisely those stimulated by the BG. Using the potential improvement in wheat yield relative to other crops, along with national wheat prices before and after the implementation of the policy, I build a measure of the potential increase in revenues due to *(i)* the technical change induced by the BG, and *(ii)* the increase in national price of wheat due to the tariff. I show that this measure is a strong predictor of the actual increase in wheat yield over the period of the policy.

Employing my index of the potential returns from the BG, I find that areas more exposed to the policy experienced an expansion in the density of economic activity, which emerged precisely over the period of the policy and persisted until today. In addition, they experienced faster industrialization. The estimated effects are sizable. A one standard deviation increase in the potential returns from the policy implies 22% higher contemporary population density and 12% of a standard deviation larger share of people in manufacturing in recent years, relative to the pre-policy period.

Given that the measure of the profitability of the BG is based on potential rather than actual returns, the estimates are unaffected by reverse causality. In addition, in the empirical specification, I control for municipality fixed effects and province by time fixed effects, thus accounting for time-invariant factors as well as time-varying characteristics across provinces (and regions) that caused differential patterns between the north and south of the country. Moreover, to take into account other possible shocks that occurred around the same time and that may be correlated with my measure of the policy, I control for time-invariant variables interacted with time indicators. Specifically, to ensure that the estimates reflect technological improvements rather than differences between wheat-suitable versus non-wheat-suitable places, I flexibly control for land suitability for wheat.[8] In addition, I control for ruggedness, which is a determinant of agricultural technology adoption. To take into account the efforts of the Fascist regime in agricultural production and malaria eradication, I flexibly control for land suitability for agriculture and the historical presence of malaria.

After providing evidence of the positive long-run effect of the policy on industri-

[8] While land suitability for wheat captures the potential level of wheat yield in the absence of advanced wheat production techniques, my measure of the potential exposure to the policy captures the *increase* in the potential revenues (and wheat yield) due to the technological improvements resulting from the BG.

alization and economic development, I turn to an analysis of potential mechanisms through which it operated. The importance of the complementarity between technological progress in agriculture and human capital accumulation has been extensively covered elsewhere (Griliches, 1963a; Nelson and Phelps, 1966; Foster and Rosenzweig, 1996). I build on this view and advance the hypothesis that the significant acceleration in technological progress resulting from the BG raised the returns from investing in human capital which, stimulating investment in education, triggered industrialization and long-term economic development.[9,10]

I investigate this hypothesis following two approaches. First, I employ cohort-specific data on educational attainment within municipalities in 1971. The idea is that the higher incentives to accumulate education determined by technical change should have been greater for people in their school age when the policy was implemented. My findings support this hypothesis. In particular, I observe that the larger the municipality exposure to the policy, the wider the gap in the 1971 educational attainment between people who were school-aged when the policy was implemented and older cohorts. Second, I employ educational attainment data across municipalities before and after the policy. I find that a two standard deviations increase in the potential exposure to the policy is associated with about one extra year of education in 1971. This result points toward the importance of human capital as a mechanism to explain the persistent effect of the BG on long-term economic prosperity.

I dig deeper into the mechanism empirically distinguishing between the effect of agricultural technological progress and the effect of the increase in price due to the tariff. In particular, I decompose my measure of the potential increase in revenues in its component given by the advanced wheat production technologies and that given by the increase in the relative price of wheat. Estimating the effect of each these two variables on various development outcomes I find that, while technological progress stimulated human capital accumulation and industrial development, the increase in wheat price had limited effects.

The estimates are robust to considering a host of potentially confounding factors, in-

[9] The role of human capital in economic development is underlined in unified growth theory (Galor and Weil, 2000; Galor, 2005) and documented empirically by Glaeser et al. (2004); Becker and Woessmann (2009); Caicedo (2014). On the positive effects of human capital on population growth, see for instance Moretti (2004); Duranton and Puga (2004); Dittmar (2011); Squicciarini and Voigtländer (2015); Dittmar and Meisenzahl (2016).

[10] Alternatively, the policy may have operated through the advancement of labor-saving technological change in agriculture, leading to the relocation of labor toward the manufacturing sector as well as out-migration more exposed areas (Bustos et al., 2016). However, this prediction is not supported by my findings that those areas experienced an increase in population.

cluding land reclamation of areas historically affected by malaria, the foundation of the fascist new cities, the presence of railroads, differences in land inequality (see e.g. Galor et al. (2009)), and the effect of limiting migration to cities above 25,000 inhabitants (Bacci, 2015), albeit unenforced (Treves, 1980), as well as taking into account spatial spillovers and potentially unobserved differences across distant municipalities. Furthermore, I find little significant evidence of alternative mechanisms such as specialization in manufacturing industries linked to wheat and agriculture or that were considered strategic by the regime, such as chemicals and war-related industries.[11] In addition, it has been shown that areas hit by WWII bombings, and thus larger reconstruction grants from the Marshall Plan, did not exhibit significant differences in agricultural technology and production during the Fascist period (Bianchi and Giorcelli, 2018), suggesting that they were not characterized by differential exposure to the BG. Finally, I investigate whether wheat suitability is conducive to economic development beyond Italy.[12] I find that, while across European regions outside Italy the link between wheat suitability on economic development is negative, within Italy it is positive. This finding suggests that wheat suitability may not be conducive to economic development in the absence of human capital augmenting technological progress in wheat production.

This paper contributes to three strands of the literature. First, it reconciles apparently contrasting views on the link between agricultural productivity and long-run growth. In particular, the findings suggest that even in an open economy, skill-biased technological progress can foster human capital formation and growth, having long-lasting beneficial effects.[13] In contrast, the limited local effects of the price increase provides novel evidence in line with the literature emphasizing that, in an open economy, a Hicks-neutral increase in agricultural productivity may not be conducive to economic development (Foster and Rosenzweig, 2004, 2007; Matsuyama, 1992; Galor and Mountford, 2008). Second, it provides novel evidence of the long-run effect of policy interventions. While development policies may generate inefficiencies and rent-seeking behaviors, they may also spur industrialization and economic development (Rosenstein-Rodan, 1943; Murphy et al., 1989; Alder et al., 2016). My results emphasize the importance of skill-biased technological progress for the effectiveness of development policies. Third, it

[11] It has been noticed that the Fascist regime's contractionary monetary policy (*Quota 90*) increased the exchange rate and tended to depressed domestic wheat prices, thus undoing the effect of the wheat tariffs and working against the BG (Segre, 1982). For a formal analysis of this mechanism, see Krugman (1987).

[12] On the importance of geography for economic development see Diamond (1998); Gallup et al. (1999); Pomeranz (2009); Henderson et al. (2017).

[13] For other mechanisms that highlight the positive effects of a rise in agricultural productivity on economic development, see Baumol (1967); Murphy et al. (1989); Gollin et al. (2002); Nunn and Qian (2011); Bustos et al. (2016). For a review of the literature, see below.

sheds light on the effects of transitory protectionist interventions. While conventional wisdom suggests that deviations from free trade are sub-optimal, there are exceptions to this view, such as the infant industry hypothesis (Hausmann and Rodrik, 2003; Stiglitz and Greenwald, 2014; Juhász, 2014). My findings provide evidence that short-run protection may foster long-run development when it stimulates human capital-augmenting technological progress and that such effect unfolds across sectors.

The paper is structured as follows. The next section briefly reviews the related literature. Section 3 describes the historical background and the set of interventions that define the BG. Section 4 describes the historical data. Section 5 documents the persistent positive effects of the BG on development and industrialization. Section 6 illustrates the importance of human capital accumulation as a mechanism through which the policy operated. The last section concludes.

2 Related Literature

This paper contributes mainly to three strands of the literature. First, it adds to the study of the link between agricultural productivity and economic development. Several scholars have emphasized that a rise in agricultural productivity is essential for urbanization and industrial development (Rostow, 1960; Nurkse et al., 1966) as it contributes to the provision of food to urban centers (Schultz, 1953) and enhances demand for manufacturing goods (Murphy et al., 1989; Gollin et al., 2002).[14] In contrast, Mokyr (1976); Field (1978); Wright (1979) emphasize that agricultural development may actually foster specialization in agriculture and delay the transition to industry. Matsuyama (1992) reconciles these views emphasizing that, while higher agricultural productivity may lead to industrial growth in closed economies, it may spur agricultural specialization in open economies and, as shown by Galor and Mountford (2008), may harness human capital formation.

This paper contributes to this literature emphasizing that technical change in agriculture may have a skilled bias nature and spur economic development in the long term. Thus, it differs from Foster and Rosenzweig (2004, 2007), who emphasize that technical change in agriculture may be Hicks neutral and hamper structural transformation; and from Bustos et al. (2016), who emphasize that technical change in agriculture may be labor saving and favor industrial growth. Furthermore, the focus of this paper on the human capital mechanism complements the finding by Gollin et al. (2018), who

[14] For an overview, see for instance Gollin (2010).

show in a cross-country setting that the Green Revolution reduced fertility and fostered economic growth.

By exploring the long-term effect of the introduction of multiple agricultural technologies, the paper contributes to the literature that analyzes the effect of single agricultural inputs, including Nunn and Qian (2011), who study the effect of the introduction of the potato; Hornbeck and Keskin (2015) who analyze the consequences of the availability of water sources; to Dall Schmidt et al. (2018), who examine the effect of clover adoption; to Andersen et al. (2016) who analyze the introduction of the heavy plow, and to Chen and Kung (2016), who study the introduction of maize.

While the analysis of agricultural productivity relates this paper to recent studies of the effects of weather-induced changes in agricultural productivity (Colmer, 2018; Santangelo, 2016), the emphasis on human capital in the agricultural sector links this work to Foster and Rosenzweig (1996), who employ a structural approach to investigate the complementarity between agricultural technological progress and human capital; to Fiszbein (2017), who studies the effect of agricultural diversity on human capital and industrialization; and to works indicating human capital as an important driver of city growth and urbanization in historical contexts (Dittmar, 2011; Squicciarini and Voigtländer, 2015; Dittmar and Meisenzahl, 2016).

Second, the paper contributes to the study of the long-run effects of policy interventions. Several theories have analyzed the effect of public spending for economic development. Rosenstein-Rodan (1943); Murphy et al. (1989); Azariadis and Stachurski (2005) indicate that, in the presence of positive externalities, public investment may spur economic development. A related body of works studies the consequences of industrial policies (Criscuolo et al., 2012; Aghion et al., 2015; Liu, 2017; Lane, 2017), the effect of place-based policies on local economic development (Glaeser and Gottlieb, 2008; Kline and Moretti, 2014a,b; Neumark and Simpson, 2015; Alder et al., 2016), and the effect of agricultural policy on physical capital (Marden, 2015). This paper complements these works as it casts light on the long-run effect of nationwide agricultural policies on local structural change and the role of the human capital mechanism.

Third, this work contributes to the literature on the consequences of temporary protection. Stiglitz and Greenwald (2014) underline the effectiveness of temporary protectionist interventions in presence of learning spillovers. Juhász (2014)'s empirical findings support the infant industry argument, which can be particularly effective in presence of within-sector externalities (Melitz, 2005; Rodriguez-Clare and Harrison, 2010). This paper complements this literature as it shows that transitory protection may trigger human capital-augmenting technological progress, which spills over across sectors. Furthermore, my finding of the limited local effect of the tariff-induced wheat price increase lends further credence to the hypothesis that, in the absence of technological improvements, protectionist interventions are not conducive to human capital accumulation (Bignon and García-Peñalosa, 2016).

3 Historical Background

In 1914, a journalist called Benito Mussolini formed the "Italian Fasci of Combat" — a movement composed by a group of men coming from different parties "brought together by their advocacy of Italy's entry into the war" and not linked "to any previously formed body of doctrine, social philosophy or economic interest" (Lyttelton, 2004). In 1922, Mussolini and his militia took advantage of a period of political instability to march on Rome and form the Fascist Government. In 1925, the dictatorship was formally declared.

At the onset of the rise of the dictatorship, the balance of payment was severely in deficit and wheat imports accounted for up to one fourth of the value of total imports (Segre, 1982). According to Mussolini's war principles, Italy could not depend on foreign countries for the supply of primary goods such as wheat. The trade collapse that characterized World War I, and the associated shortage of primary goods, was a fundamental motive that induced Mussolini to increase domestic wheat production and achieve self-sufficiency.

When the Regime came to power, Italian agriculture was mainly primitive[15] (Lorenzetti, 2000). In particular, seed selection was basically absent and there was scarce use of fertilizers and machines. In addition, the international price of wheat was low and domestic producers were not competitive. In 1925, the regime implemented the "Battle for Grain" (*Battaglia del Grano*) with the aim of increasing wheat yield and achieving self-sufficiency in the production of this primary crop.

A first set of interventions was introduced to stimulate wheat productivity. To solve the seed problem, public investments were made in R&D for the selection of wheat varieties that could maximize yield per hectare (Serpieri and Mortara, 1934). The Regime financed Nazareno Strampelli, a scientist who devoted his life to creating improved

[15] However, significant differences across regions existed. For instance, agriculture on the Po valley was typically more advanced than the rest of the country. I take into account these preexisting differences using province fixed effects.

wheat varieties. He was the first to apply Mendel's laws to plants and wheat breeding, and his seeds incorporated traits for rust resistance, early maturity, and short straw. Strampelli's seeds would be used in other countries such as Argentina, China, and Mexico and would become instrumental for the creation of the high-yielding varieties developed by Borlaug, contributing to the advent of the Green Revolution (Salvi et al., 2013).

In addition, wheat producers were subsidized for purchasing agricultural machinery, such as tractors and threshers. At the same time, the Regime implemented regulations that reduced the price of fertilizers. As a result, the use of commercial fertilizers rose by more than 50% in the first four years of the policy (Hazan, 1933).[16] The availability of new agricultural technology was extensively advertised through the Fascist propaganda and the "Traveling Chairs of Agriculture" (*Cattedre Ambulanti di Agricoltura*) — an institution originating in the eighteenth century to spread agricultural knowledge. Further incentives to intensify wheat production were given by an increase in the wheat price mainly due to a tariff on wheat imports that exceeded 100% of the international price of wheat (see figure 1a).[17]

The BG was effective in achieving self-sufficiency in wheat. After a substantial increase in wheat price (figure 1b),[18] a decrease in wheat imports followed (figure 1c), which were substituted by greater domestic wheat production (figure 1d).[19] Wheat production soared predominantly through increases in productivity, making the BG a productivity-oriented agricultural policy (Serpieri and Mortara, 1934; Profumieri, 1971; Cohen, 1979; Segre, 1982). Consistent with this historical literature, figure 2 shows that the increase in domestic wheat production over the period of the policy was indeed predominantly governed by the increase in wheat productivity, rather than changes in cultivated land (which is mostly constant) or in its share devoted to wheat (which displays only minor increases toward he end of the policy period). The wheat productivity increase was associated with a substantial 85% rise in the adoption of more advanced agricultural machinery[20] and unprecedented increases in the adoption of the advanced wheat seeds and fertilizers (Cohen, 1979). Finally, the BG stimulated progress in agri-

[16] Furthermore, local and national prizes were given to the most modern and productive wheat producers (Serpieri and Mortara, 1934).

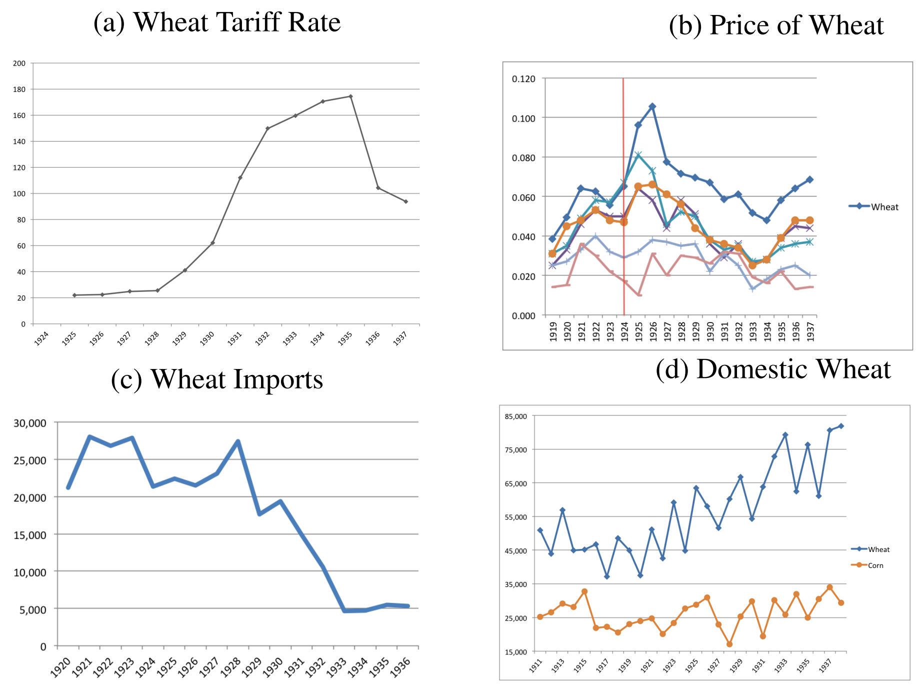
[17] Simultaneous interventions to keep the wheat price high included compulsory milling — requiring the use of at least 95% of domestic wheat in any production process — and subsidies to store wheat in silos during the wheat season.

[18] The real price of wheat displays a similar pattern, as shown in figure 6

[19] There is little decrease in the imports of other commodities such as steel and oil, as depicted in figures 7 and 8, respectively

[20] A well known new piece of equipment was the 1935 tractor Landini Vélite. The name comes from the title that Mussolini gave to the farmers with outstanding wheat productivity (Benfatti, 2000).

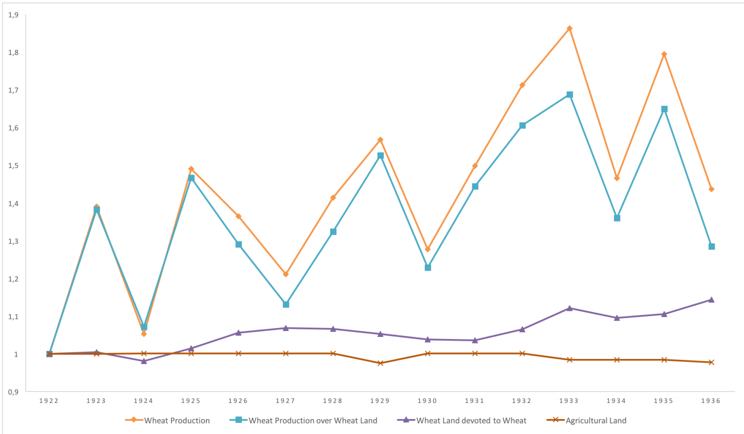
Figure 1: The Effectiveness of the *Battle for Grain*



Notes: The figures show that the *Battle for Grain* was effective in boosting domestic wheat production. Figure 1a depicts the import tariff applied to soft wheat relative to its international price (similar tariffs were applied to hard wheat as shown by the similarity of their prices in appendix figure 9). Figure 1b shows the spike in wheat prices due to the tariff. Figure 1c shows that wheat imports declined (thousand of quintals, source: ISTAT), with the exception of 1928 and 1929, when the United States wheat price went down significantly which was compensated by a substantial increase in the tariff (Lorenzetti, 2000, p. 262). Figure 1d shows that, in contrast to corn, wheat production increased over the period of the policy (thousands of quintals, source: ISTAT).

cultural education and, through the work given in practical agricultural schools and universities, fostered modernization in the agricultural sector (Hazan, 1933).

Figure 2: The *Battle for Grain* and Wheat Productivity



Notes: This figure illustrates that the increase in national production of wheat over the period of the *Battle for Grain* was predominantly explained by the increase in wheat productivity. In particular, I decompose national wheat production in the product of wheat production per hectare of land devoted to wheat, land devoted to wheat over agricultural land, and agricultural land. In addition, the figure shows that during the *Battle for Grain* changes in agricultural land were negative and small in magnitude.

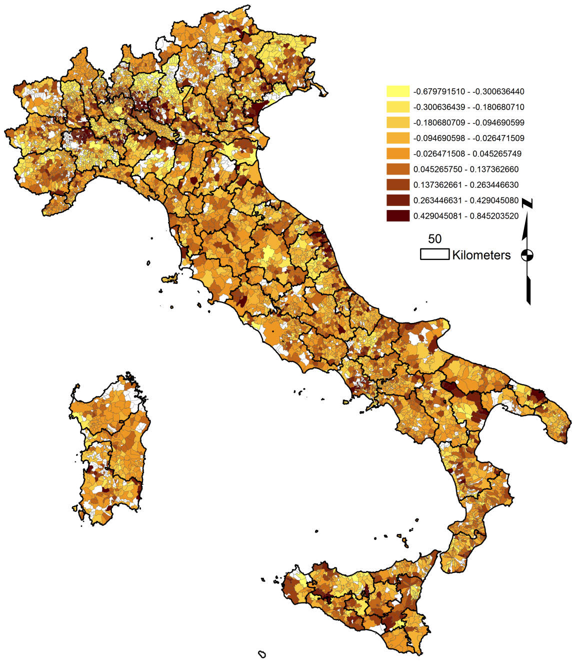
4 Data

This section describes the agricultural data employed in the empirical analysis. A more detailed description of data and sources is in appendix E. Wheat productivity data are compiled from the 1929 Italian Census of Agriculture, held at the municipality level (about 7000 in current borders). I measure the increase in wheat productivity due to the BG using the change in tons of wheat produced per hectare over the years of the policy.[21] The census provides data yields per hectare in 1929 (q^w_{29}) — four years after implementation — and average wheat yield per hectare over the years 1923-1928 ($\bar{q}^w_{23-28}$). As described in the 1929 Census of Agriculture, in the Italian peninsula, the seeding period for wheat goes from September to the beginning of January. The policy was introduced in July 1925, thus before the wheat seeding period of that year. Therefore, the first harvest after the adoption of the policy was in 1926. Which implies that $\bar{q}^w_{23-28}$ is the average wheat yield three years before and three years after the introduction of the policy.

I measure the increase in wheat yield using $\Delta q^w \equiv (q^w_{29} - \bar{q}^w_{23-28})$. Figure 3 illustrates a map of the increase in wheat yield across Italian municipalities. Panel 4a depicts a

[21] More than 87% of the municipalities increased wheat yield over the first years of the policy, suggesting that the measure is capturing the effect of the BG on wheat productivity in the country as a whole.

Figure 3: The Increase in Wheat Yield 1923-1929



Notes: Map of the increase in wheat yield per hectare over the years 1923 - 1929 across municipalities, after controlling for province-fixed effects

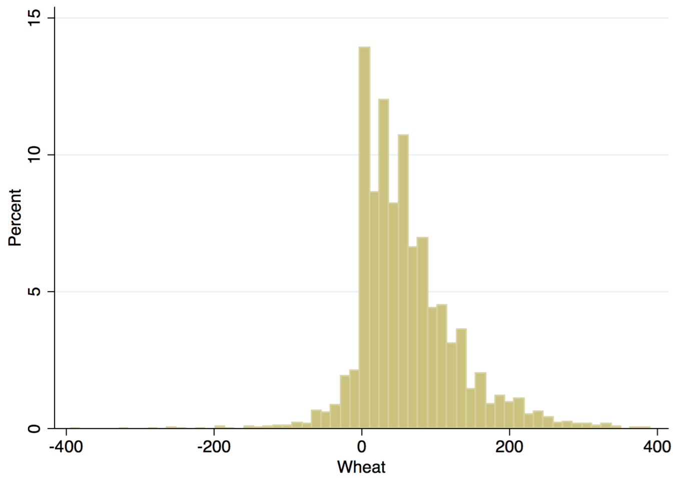
histogram of the variable expressed in units so as to be comparable with other crops, which are depicted in figure 4b. From the comparison of the two panels it clearly emerges that, in the early years of the BG, the increase in productivity was experienced mainly in wheat production.

The variable of interest, Δq^w, actually underestimates the actual change in wheat productivity for two reasons. First, because the latest period in which wheat yield is observed is 1929, ten years before the end of the BG. Second, $\bar{q}^w_{23-28}$ includes some post-policy years, in turn implying the presence of non-classical measurement error[22] which cannot be solved by an Instrumental Variable approach. Therefore, I follow Chen et al. (2005a,b) and, in section 5.2, I use an auxiliary data set from FAO's GAEZ v3 which is unaffected by measurement error and provides exogenous variation based on geographic conditions. Furthermore, I show in the appendix section F that using the variable Δq^w as as explanatory variable of interest would imply a bias in the OLS estimates which is opposite in sign to the coefficient of interest.

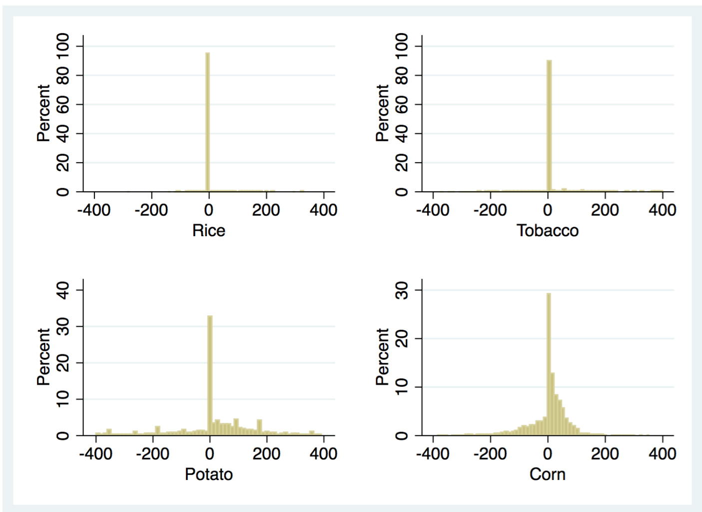
[22] The observed variable of interest can be written as the sum of the latent unobserved variable of interest and a measurement error term: $\Delta q^w = (q^w_{29} - q^w_{23}) - (\bar{q}^w_{23-28} - q^w_{23}) \equiv \Delta q^*_w - \xi$. Given that $Corr(\Delta q^*_w, \xi) \neq 0$, the observed variable of interest is affected by non-classical measurement error (see appendix section F).

Figure 4: The Change in Productivity for Wheat and Other Crops 1923-1929

(a) Increase in Wheat Yield, 1923-1929



(b) Limited Change in the Yields for Other Crops, 1923-1929



Notes: The panels show the changes in the yields per hectare for wheat and other crops. The panels are comparable as they are valued at real 1919 prices. Panel (a) shows the substantial increase in wheat yield over the first year of the policy. Panel (b) shows the limited changes in other crops. In particular, the variable represented in each plot is $\Delta\tilde{q}_i^j * P_{19}^j$ where $\Delta\tilde{q}_i^j$ is the change in yield per hectare for crop j in municipality i over the years 1923-1929, and P_{19}^j is national real price for crop j in 1919, base year 1911 *lire*. See main text and appendix for variable definition and sources.

5 Empirical Analysis

In this section, I study the long-run effects of the BG on industrialization and economic development across Italian municipalities. In section 5.1, I employ development outcomes before and after the policy to investigate the emergence and persistence of a relation between the increase in wheat productivity over the years of the BG and economic development. In section 5.2, I examine the presence of a causal link exploiting as exogenous sources of variation geographic conditions which entailed differential exposure to the BG.

5.1 Increase in Wheat Yield and Development

In the following, I document that areas where wheat yield increased over the period of the policy experienced significant expansions in economic activity and industrialization that emerged only after the introduction of the BG and persisted until today.

I estimate a flexible specification that allows the change in wheat yield to have a time varying relation with the outcome variables of interest. The estimated model is given by:

$$Y_{it} = \alpha_i + \alpha_{ct} + \beta_t \Delta q^w_{23-29,i} + \varepsilon_{it} \qquad (1)$$

where Y_{it} represents an outcome variable for municipality i at time t. In particular, as outcome variables I employ the logarithm of population density, as a measure of the density of economic activity, and the share of the population working in manufacturing as a measure of industrial development. α_i are fixed effects at the level of municipality i, α_{ct} are province by year fixed effects; $\Delta q^w_{23-29,i}$ is the increase in wheat yield over the years 1923-1929 in municipality i. The coefficient of interest, β_t, is the difference in the outcome variable between year t and a reference year associated with a one standard deviation increase in $\Delta q^w_{23-29,i}$.[23] Given that β_t can change over time, my hypothesis is that β_t is approximately zero for the periods before implementation and positive afterwards.[24]

Substantial differences in economic development across Italian regions were already

[23] The reference year e in the analysis is 1911. As explained in the following, the results are not affected by the choice of the reference year.

[24] Note that, as shown in section 3, the increase in wheat productivity observed over the period of study, together the persistent availability of the agricultural technology introduced and the persistence observed in the wheat price shock, suggest that wheat yield levels are not strongly mean reverting, making the specification immune to the Ciccone (2011)'s critique.

significant before the BG and the debate about the "Southern Question" began as early as the 1870s. Therefore, to take into account differential trends across provinces (and regions), I control for province by time fixed effects using historical provinces as of 1929.[25] The focus on within-province variation takes into account unobserved factors - such as heterogeneity in culture or informal institutions - that vary across provinces and have been indicated as determinants of the Italian regional imbalances. In addition, it takes into account potential differences in the data collection process, which was performed at the level of historical provinces. Finally, I control for fixed effects at the level of the municipality, ensuring that time-invariant potentially confounding factors — such as geography and deep-rooted historical factors — are taken into account.

Figure 5, panel (a), depicts the regression coefficients from estimating equation 1 using as an outcome variable the natural logarithm of population density. It also shows the 95% confidence intervals based on robust standard errors clustered at the province level.[26] The estimated coefficients fully comply with the hypothesis of a positive effect of the policy on economic development. In particular, the estimates are small in magnitude and not statistically significant in the decades before implementation. The estimates then become positive and statistically significant in 1936, precisely when the BG was operating. In addition, the coefficients grow in magnitude in the decades after the repeal of the BG and until today. This finding is consistent with the hypothesis that the policy, in increasing wheat productivity, unexpectedly triggered a cumulative process of development that unfolded over the course of the twentieth century, the period in which the contribution of the agricultural sector to output formation diminished.

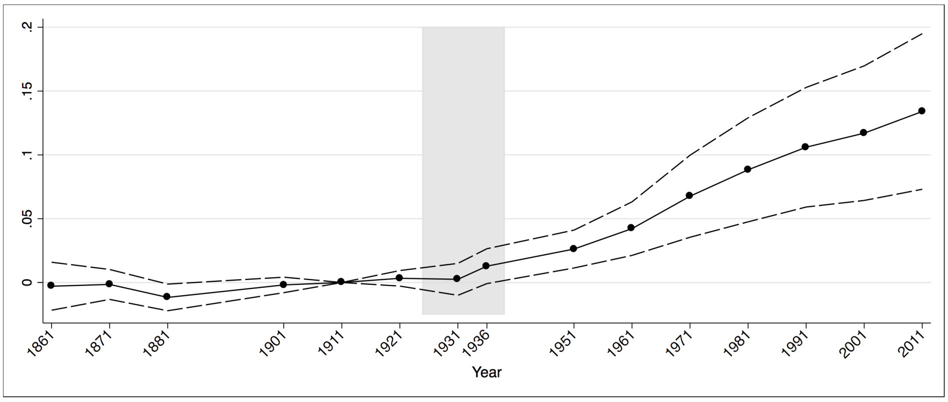
Figure 5, panel (b), uses as an outcome as an outcome the share of population in manufacturing. The figure shows that municipalities were wheat yield increased due to the BG experienced an expansion in industrial development from 1951 onward, about a decade after the end of the BG. This finding is consistent with the hypothesized effect of the BG on human capital accumulation, which was conducive to industrialization in later stages. The estimated coefficients for the year 2001 indicates that municipalities experiencing a one standard deviation larger increase in wheat yield over the period of the policy are characterized by a 13% larger population density and 8.5% of a standard deviation larger share of people working in the manufacturing sector, relative to 1911.

[25] In 1929, there were 91 provinces in current borders. Controlling for 110 provinces (NUTS 3) as of 2010 rather than the historical ones does not affect the results.

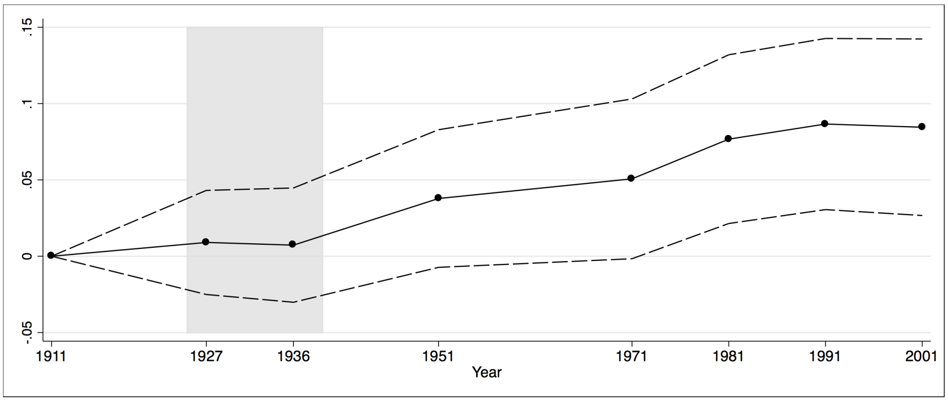
[26] This approach takes into account serial correlation within the cluster and over time. Using Conley (1999)'s methodology with cutoffs at 50, 100, and 200 kilometers, I estimate standard errors that are smaller in magnitudes than those estimated using clustered standard errors. Results available upon request.

Figure 5: The Increase in Wheat Yield and Long-Term Development: Flexible Estimates

(a) Population Density



(b) Industrialization



Notes: The figures depict the coefficient estimates from a flexible specification of the log of population density (panel (a)) and the share of manufacturing population (panel (b)) on the increase in wheat yields over the years 1923-1929. The regression includes municipality-fixed effects and province by time-fixed effects. The confidence intervals at 95% are based on province-level clustered standard errors. See appendix table A1 for the estimated coefficients. No Population Census was conducted in 1891 or 1941 See main text and appendices for variable definition and sources.

Given the use of variation within provinces, the estimates shown in this section are based on the comparison between municipalities very close to each other and thus very similar under several dimensions. However, there may be threats to identification, such as in the case of reverse causality. In the following section, I address this potential concern.

5.2 Empirical Strategy: the Potential Revenue Index

5.2.1 The Construction of the Index

In this section, I employ exogenous geographic variation to construct a variable that measures the differential exposure to the BG. The need for exogenous sources of variation to identify the causal effects of the BG on economic development is due to two reasons. The first is the presence of measurement error in the historical data, which may imply downward bias in the OLS estimates (see appendix F). The second is the potential concern for identification. For instance, areas that experienced faster economic growth over the period of study increased their local demand for agricultural goods, in turn stimulating technology adoption in wheat.

The BG entailed a technical change in wheat production due to the availability of improved wheat seeds together with subsidies for machinery and fertilizers. At the same time, the wheat tariff caused a positive shock in the national price of wheat relative to other crops, further enhancing farmers' incentives to adopt the more modern wheat production techniques. Thus my variable has to combine two sources of variation: the shock in the national wheat price caused by the BG and the *potential* increase in wheat yield due to the adoption of the new inputs as determined by geographic characteristics.

I use two sources of data. First, I employ national prices for wheat and major crops[27] I convert prices into real terms using the Consumer Price Index by Malanima (2002). Second, I use production capacity per hectare for wheat and other crops as determined by geographic characteristics from the Food and Agriculture Organization of the United Nations (FAO)'s Global Agro-Ecological Zones (GAEZ) v3.0.[28]

[27] Data source: ISTAT (*http://seriestoriche.istat.it* - Table 21.1), last access November 2015.

[28] The data are based on the average geographic characteristics over a thirty-year period. Given that geographic conditions are slow moving, these data are a plausibly exogenous source of variation to identify the shock resulting from the BG.

Production capacity is estimated assuming low and intermediate levels of inputs.[29][30] Potential yields with low input levels are based on a model developed by FAO GAEZ that considers limited seed selection and no use of machines and fertilizers. These conditions are very similar to the obsolete wheat production techniques used prior to the BG (Lorenzetti, 2000). Potential yields with intermediate input levels are based on a model that considers the use of improved varieties, mechanization, and fertilizers, which are precisely the wheat production techniques stimulated by the BG. Therefore, the improvements in the potential wheat yield from low to intermediate levels is the ideal source of cross-sectional variation to identify areas which had greater exposure to the technological progress resulting from the BG.

I use these data to construct a measure of the potential revenues of wheat relative to competing crops in a given year and for a given level of inputs, which I call the Potential Revenue Index (PRI).

The PRI before the policy (time 0) in municipality i is given by:

$$PRI_{0,i} = \sum_c \frac{\bar{p}_0^w \hat{q}_{c,(low)}^w}{\sum_{j \in \mathscr{C}_c} \bar{p}_0^j \hat{q}_{c,(low)}^j / |\mathscr{C}_c|} dP(c|c \in i) \text{ where } w \notin \mathscr{C}_c \tag{2}$$

where $\bar{p}_0^j$ is the average national real price of crop j over the years before the policy (i.e. $t = 0$);[31] $\hat{q}_{c,(low)}^j$ is the potential yield per hectare of crop j with low inputs in cell c (where $j = w$ refers to wheat); $\mathscr{C}_c$ is the set of productive crops in cell c that are not complementary to wheat production.[32]; $P(c|c \in i)$ is the intersection between the area of cell c and the area of municipality i.

The numerator of equation 2 represents the potential revenues per hectare from producing wheat with pre-policy national prices and technologies. The denominator is

[29] Production capacity is also estimated assuming a high level of inputs which, being based on the most modern agricultural techniques available today, is not appropriate to represent the Italian technological standards from the first half of the last century. Nevertheless, results are robust to the use of high rather than intermediate input levels (see appendix table B8 and B9).

[30] For irrigation conditions, I use rain-fed conditions as they are unaffected by the actual presence of irrigation infrastructure. See the appendix for a description of the data.

[31] Given that the policy was implemented in 1925, the years considered before the policy are between 1919 and 1924. I do not use prices before 1919 because during World War I (1914-1918) prices do not reflect market forces. I use real prices averaged over the years before the policy so as to prevent fluctuations in prices in one specific year driving the results. Pre-policy periods were characterized by *laissez faire* and, in particular, by a low degree of protectionism.

[32] Employing only productive crops ensures that the PRI is not driven by the number of crops whose productivity is close to zero, and hence by soil fertility. I consider productive crops those with potential revenues per hectare above a cutoff of one *lire* at 1911 prices.Results are unaffected by the choice of the cutoff as shown in tables B10 and B11 in the appendix.

the average potential revenues from productive crops that are potentially alternative to wheat. Thus, the *PRI* represents the potential revenues per hectare from producing wheat relative to the forgone revenues from competing crops, valued at pre-policy prices and technologies.[33]

I capture the higher profitability from producing wheat after the implementation of the BG by calculating the *PRI* with the post-policy prices and wheat production technologies. In mathematical terms:

$$PRI_{1,i} = \sum_c \frac{\bar{p}_1^w \hat{q}_{c,(int)}^w}{\sum_{j \in \mathscr{C}_c} \bar{p}_1^j \hat{q}_{c,(low)}^j / |\mathscr{C}_c|} dP(c|c \in i) \text{ where } w \notin \mathscr{C}_c \tag{3}$$

where p_1^j is the price of crop j after the introduction of the policy ($t = 1$).[34] $\hat{q}_{c,(int)}^w$ is the potential wheat yield per hectare with intermediate inputs in cell c.[35]

Therefore, I measure the increase in the profitability from wheat production due to the BG with the growth in the *PRI*. Expressed mathematically:

$$\Delta lnPRI_i = lnPRI_{1,i} - lnPRI_{0,i} \tag{4}$$

which is the growth in the *PRI* due to *(i)* technological improvements in wheat and *(ii)* the shock in the national wheat price due to the protectionist interventions. Figure 10 in the appendix displays a map of this variable.

Having built a measure of the exposure to the BG, I turn to investigating whether this variable captures meaningful variation in the actual increase in wheat yield. As explained in section 4 the increase in wheat yield is affected by non-classical measurement error which, as shown in appendix F, may underestimate the predictive power of the growth in the PRI. Nevertheless, by regressing the increase in wheat yield over the years 1923-1929 on the growth in the PRI may still be informative on whether such a variable captures the exposure to the policy.[36] Figure 6 depicts the relationship between

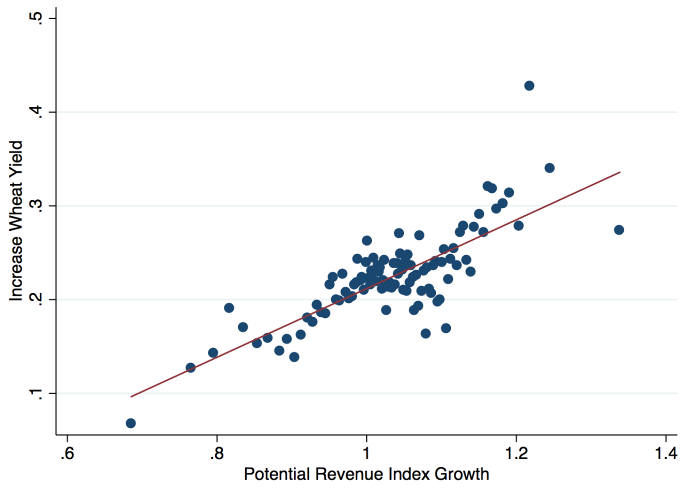
[33] Results are robust to the inclusion of complementary crops, see tables B8 and B9. Crops that are competing with wheat are Citrus, Oats, Olives, Potatoes, Tomatoes. Complementary crops are legumes, maize, rice, and tobacco (Sulieman and Tran, 2015; Allen, 2008; Berzsenyi et al., 2000), as also indicated in the 1929 Census of Agriculture, and 1936 Enciclopedia Treccani (see `http://www.treccani.it/enciclopedia/tabacco_(Enciclopedia-Italiana)`, last access April 2016).

[34] The years considered are from implementation, 1925, until 1929, so as to avoid the years of the Great Depression, which may have an independent effect on the national wheat price.

[35] Although the intermediate level of inputs seems more appropriate to capture the technological level after the technical change induced by the policy, the results are robust to the use of a high level of inputs instead of the intermediate one. See appendix tables B8 and B9.

[36] The linear-logarithm relation can be explained by risk-averse farmers and uncertainty in the returns from the new wheat production technologies (Hiebert, 1974; Foster and Rosenzweig, 2010).

Figure 6: The Exposure to the *Battle for Grain* and the Wheat Yield Increase



Notes: This figure shows a binned scatter plot of the relationship between the increase in wheat yield over the years from 1923 to 1929 and my measure of the potential returns from the Battle for Grain, conditioning on province-fixed effects. For ease of visualization, the binned scatter plot groups observations in 100 equal sized bins. See appendix figures 11a and 11b plain scatter plots with or without fixed effects.

these two variables, the estimates are in table 1.

Column 1 shows the unconditional relation between the increase in wheat yield at the time of the policy and my measure of exposure to the policy based on geographic variation. The standardized coefficient is large and highly significant, suggesting that a growth in the PRI captures meaningful variation in the increase in wheat yield. Furthermore, I show in the appendix section F that, due to non-classical measurement error in the outcome variable, the estimated coefficient is a lower bound of the parameter of interest.

Column 2 adds province fixed effects to ensure that the coefficient is not polluted by unobservable differences across municipalities that are far away from each other. The coefficient of interest actually increases in magnitude, suggesting that unobservable factors, as well as non-classical measurement error in the outcome variable, imply negative bias in the estimated coefficient.

Column 3 includes land suitability for wheat as a control. As expected, areas more suitable for wheat experienced larger increase in wheat yield. This finding can be explained by preexisting knowledge in agricultural production that was instrumental for increasing wheat productivity during the BG. As a result, wheat suitability captures useful variation in geographic conditions which make some municipalities more exposed to the policy, in turn reducing the coefficient of interest, which remains positive and statistically significant.

Columns from 4 to 7 include land suitability for agriculture, ruggedness, and the presence of malaria, respectively. The coefficient is robust to these additional controls which, as evident from the R-squared, have a marginal effect on the predictive power of the estimated model. These estimates suggest that geographic suitability for wheat takes fully into account the initial differences in geographic conditions and thus my variable captures the additional increase in wheat yield due to the BG.

Table 1: The Predictive Power of the PRI. OLS

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Δ Wheat Yield 1923-1929						
$\Delta lnPRI_{(1919-29)}$	0.2664***	0.3043***	0.1381***	0.1356***	0.1234***	0.1142***
	[0.013]	[0.018]	[0.019]	[0.019]	[0.020]	[0.020]
Wheat Suitability			0.2642***	0.2538***	0.2379***	0.2374***
			[0.015]	[0.016]	[0.018]	[0.018]
Observations	6,662	6,662	6,662	6,662	6,662	6,662
Province FE	No	Yes	Yes	Yes	Yes	Yes
Wheat Suitability	No	No	Yes	Yes	Yes	Yes
Agric. Suitab.	No	No	No	Yes	Yes	Yes
Ruggedness	No	No	No	No	Yes	Yes
Hist. Malaria	No	No	No	No	No	Yes
F-stat (K-P)	434.4	277.1	52.41	50.42	38.49	32.98
Adj. R^2	0.0702	0.417	0.448	0.448	0.448	0.450
R^2 Within	-	0.0483	0.0984	0.0994	0.100	0.103

Notes: This table shows that the potential returns from the *Battle for Grain* ($\Delta lnPRI$) is a strong predictor of the actual change in wheat productivity over the period of the period from 1923 to 1929, even controlling for wheat suitability, province-fixed effects, and other controls.. Kleibergen-Paap's F-statistic refers to $\Delta lnPRI$. Robust standard errors in brackets. Observations are at the municipality level. See the main text and appendices for definitions of variables and sources.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

In the appendix section B.1, I demonstrate that both the increase in wheat prices and the improvements in the wheat production technologies are important determinants of the increase in wheat yield over the period of the policy. Furthermore, I show robustness checks in support of the validity of the *PRI* growth as a measure of the differential exposure to the BG.

5.2.2 Flexible Estimates

This section exploits the temporary nature of the BG and cross sectional variation in the PRI to estimate the effect of the policy on industrialization and population density in the long run.[37] The identifying assumption is based on the argument that the interaction

[37] A vibrant literature employs population data as a measure of economic development and urbanization during pre-industrial periods (Nunn and Qian, 2011; Dittmar, 2011; Squicciarini and Voigtländer,

between my measure of the intensity of the exposure to the policy, the growth in the PRI, and the time when the policy was introduced is exogenous. I support this assumption demonstrating that the measure of the exposure to the BG became economically and statistically significant only after the introduction of the policy. For this purpose, I estimate the following model:

$$Y_{it} = \alpha_i + \alpha_{ct} + \beta_t \Delta lnPRI_{(1919-29),i} + \theta_t \mathbf{X} + \varepsilon_{it} \quad (5)$$

where Y_{it} is a development outcome — log of population density or manufacturing population share — in municipality i at time t; α_i are fixed effects at the level of municipality i; α_{ct} are province-year fixed effects; $\mathbf{X}$ is a set of time-invariant controls interacted with year indicators. In particular, I control for land suitability for wheat, as well as other geographic controls that will be explained in the following. The coefficient estimates, β_t, measure the difference in the outcome between year t and a reference year associated with a one standard deviation increase in the growth of the PRI. While municipality fixed effects take into account time-invariant characteristics at the level of municipalities, province by year fixed effects control for differential time trends across provinces.

Estimates are robust to the inclusion of flexible controls. During the period of study, significant progress in malaria eradication was made (Snowden, 2008). Malaria eradication might be correlated with changes in agricultural productivity and independently affect economic development. To take into account this potentially confounding factor, I flexibly control for the presence of malaria before the policy. This variable takes value one if the municipality was affected by malaria in 1870. Places naturally more suitable for agriculture may have had economic advantages that were independent of the BG. To take this element into account, I flexibly control for suitability for agriculture measured by the Caloric Suitability Index (CSI) developed by Galor and Özak (2016). The index measures the average calories per hectare that can be produced based on geographic conditions.[38] I account for geographic diversity by flexibly controlling for the standard deviation of elevation (Michalopoulos, 2012). I correct inference clustering the standard errors at the province level so as to allow the error term to be serially correlated over time and spatially correlated across municipalities within provinces.

Figure 7a shows the estimated coefficients using as an outcome the natural logarithm

2015). Furthermore, Glaeser et al. (1995) and Gonzalez-Navarro and Turner (2016) use population data in contemporary periods as a measure of urbanization.

[38] It has been shown that the CSI is a measure of soil fertility superior to those previously used in the literature (Galor and Özak, 2015).

of population density (coefficients are reported in the appendix table A2).The estimated coefficients show that the exposure to the BG had a positive effect on population that emerged precisely over the period of the policy (1925-1939). Consistent with the hypothesis that the policy triggered a cumulative effect on economic development, the estimated coefficients grow in magnitude even after the repeal of the policy. Such an effect persisted through recent times, when the contribution of agriculture to output formation was marginal (2.2% of GDP in 2014, ISTAT). The coefficient for 2011 is approximately 21%, meaning that a one standard deviation increase in the growth of the PRI can explain a 21% higher population density in 2011 compared with 1911.

Figure 7b illustrates the estimates using as an outcome the share of the population working in manufacturing (standardized). The estimates become positive and statistically significant only in 1951. The coefficient for 2001 is approximately 12%, meaning that a one standard deviation increase in my measure of the potential returns from the policy can explain a 12% of a standard deviation increase in industrialization in 2001 compared with 1911.

5.2.3 Baseline Specification

In the following, I estimate a more parsimonious model, which has two advantages. First, it allows the estimates to be independent of a reference year. Second, it allows to test for placebo timings of the policy. In particular, I estimate the following equation,

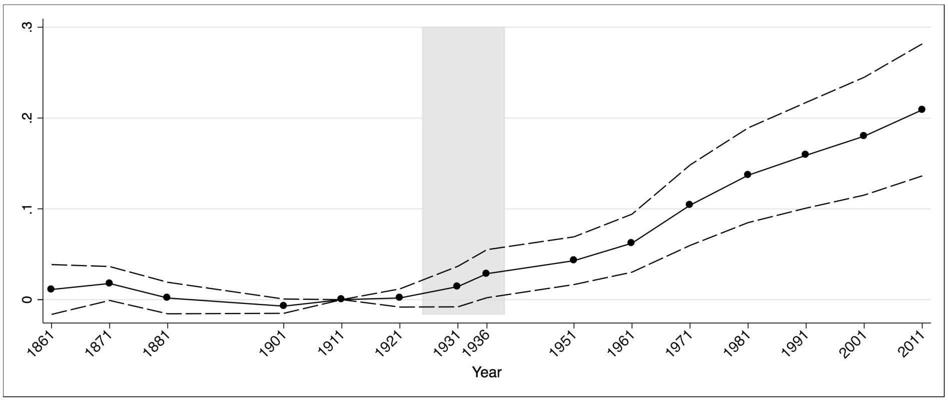
$$Y_{it} = \alpha_i + \alpha_{ct} + \beta \Delta lnPRI_{(1919-29),i} \times Post_t + \theta_t \mathbf{X} + \varepsilon_{it} \tag{6}$$

where α_i, α_{ct} are fixed effects for municipality, and province-year. *Post* is a dummy that takes value one if $t \geq 1925$, the year in which the policy was implemented. **X** represents a set of controls interacted with time dummies: land suitability for wheat, presence of malaria in 1870, land suitability for agriculture (CSI), and standard deviation of elevation. In the appendix tables A5 and A6 I perform a simpler approach regressing the changes in the log of population and in the share of people in manufacturing on the growth in the PRI. Scatter plots are reported in appendix figures 12 and 13.

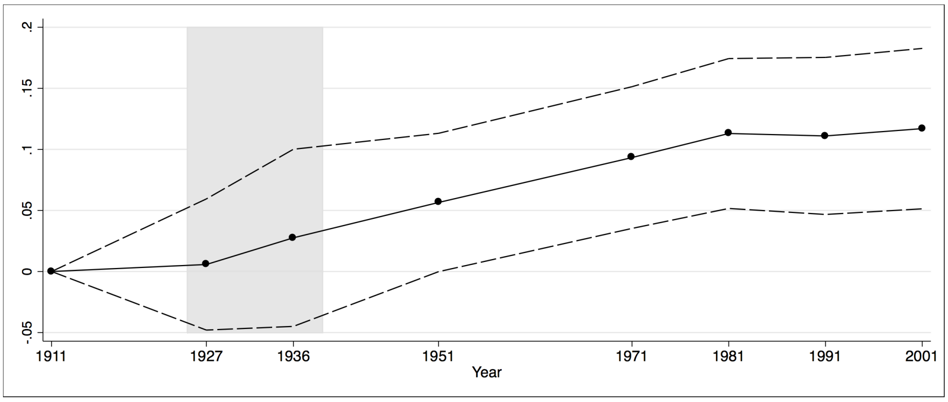
Table 2 shows the estimates from the baseline specification with population density as an outcome variable. Consistent with the hypothesis of a positive effect of the BG on long-term economic development, the coefficient is positive and statistically significant across all specifications. In all specifications, I control for province by time fixed-effects and municipality fixed effects. In column 1, I also flexibly control for land suitability

Figure 7: The *Battle for Grain* and Long-Term Development: Flexible Estimates

(a) Population Density



(b) Industrialization



Notes: The figures depict the coefficient estimates of the effect of the exposure to the *Battle for Grain*, captured by the Potential Revenue Index, on economic development in the long term. Panel (a) employs as an outcome the log of population density. Panel (b) employs as an outcome the share of manufacturing population. The regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). No Population Census was conducted in 1891 or 1941. See the main text and appendices for variable definition and sources.

for wheat, so as to compare places with similar levels in potential wheat yield with low inputs and minimizing concerns on potential time-varying effect of geographic conditions that make areas more suitable for wheat. The coefficient implies that a one SD increase in the exposure to the policy led to 11.5% higher population density after the policy.[39] In column 2, I flexibly control for suitability for agriculture. Interestingly, the coefficient slightly increases in magnitude, suggesting that the absence of this control may imply a negative bias in the estimated coefficients. In column 3, I also control for standard deviation of elevation. In this case the estimated coefficient slightly decreases in magnitude, which is possibly due to the role of ruggedness in influencing technological adoption in agriculture, in turn capturing useful variation in the index of the potential returns to the policy. In column 4, I flexibly control for the historical presence of malaria. This control increases the coefficient of interest, suggesting that areas historically affected by malaria experienced an improvement in agricultural development as a consequence of the eradication but display economic performance, entailing a negative bias in the estimated coefficient. The estimates imply that a one standard deviation increase in the exposure to the policy implies on average a 10% higher population density after the introduction of the policy.

Table 3 reports similar specifications with the use of the share of population employed in manufacturing as a measure of industrialization. The coefficient of interest in column 4 implies that a one standard deviation higher exposure to the policy is on average associated with 7.65% of a standard deviation higher industrialization after the introduction of the policy.

It is difficult to disentangle empirically whether the estimated effect of the policy is due to changes in the steady state in growth rates, or occurs through convergence of the economy to a new steady state in levels. The baseline empirical model estimated in this section has the advantage of being simple and parsimonious. However it imposes a level-effect structure on the estimates. Therefore, in light of the flexible estimates shown in section 5.2.2, it may be argued that the policy stimulated a cumulative process of economic development that translated into different trends in the growth rates. This possibility is explored with a different empirical specification in the appendix tables A3 and A4.

[39] To express the coefficient in terms of tons of wheat per hectare, I employ the result in table 1, to find that a one SD deviation higher increase in wheat yield over the early years of the policy (which is about .22 tons per hectare, see table E1) is associated with 83% higher population density in the post policy period (.1152/.1381). This estimate is equivalent to the Two Stage Least Squares estimator. However, the estimate is an upper bound of the true parameter due to measurement error in the wheat yield data (see appendix F for a proof). With additional assumptions on the structure of the error term (see appendix F), the estimated parameter is approximately 63% (.1152/.1831).

Table 2: Baseline Specification: Population

	(1)	(2)	(3)	(4)
Dependent Variable: *Ln Population Density*				
$\Delta lnPRI_{(1919-29)} \times Post$	0.1152***	0.1181***	0.0981***	0.1001***
	[0.022]	[0.022]	[0.022]	[0.022]
Wheat Suitability	Yes	Yes	Yes	Yes
Agric. Suitab.	No	Yes	Yes	Yes
Ruggedness	No	No	Yes	Yes
Hist. Malaria	No	No	No	Yes
Observations	95,657	95,657	95,657	95,657
Adjusted R-squared	0.918	0.919	0.919	0.919
R^2 Within	0.0941	0.0984	0.106	0.106

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values larger or equal to 1925. All regressions include municipality fixed effects, province-year fixed effects. Each control is interacted with year indicators. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table 3: Baseline Specification: Manufacturing

	(1)	(2)	(3)	(4)
Dependent Variable: *Share of Population in Manufacturing*				
$\Delta lnPRI_{(1919-29)} \times Post$	0.0813***	0.0813***	0.0745***	0.0763***
	[0.025]	[0.025]	[0.026]	[0.025]
Wheat Suitability	Yes	Yes	Yes	Yes
Agric. Suitab.	No	Yes	Yes	Yes
Ruggedness	No	No	Yes	Yes
Hist. Malaria	No	No	No	Yes
Observations	50,547	50,547	50,547	50,547
Adjusted R-squared	0.606	0.606	0.607	0.608
R^2 Within	0.0138	0.0142	0.0159	0.0173

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values larger or equal to 1925. All regressions include municipality fixed effects, province-year fixed effects. Each control is interacted with year indicators. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

5.3 Placebo Timing of the Policy

Prior to the introduction of the policy there is no reason to expect a positive effect of the BG on local economic activity. Therefore, I expect the interaction between my measure of the exposure to the policy and placebo timings of the policy to be of little statistical and economic relevance. In the following, I investigate this hypothesis examining the significance of placebo cutoff breaks before the policy. Table 4 illustrates the results.

In particular, columns 1 and 2 display the estimates using the relevant timing of the policy (1925). Column 1 reports the estimates on the entire sample, from 1961 to 2011. Column 2 shows estimates on a restricted sample that covers 50 years: from 1911 to 1951. The time window analyzed is indicated in column headings. Despite the reduction in the number of observations, the estimated coefficient for the restricted period is positive and statistically significant, suggesting that the policy had a short-run effect on economic development that unfolded already by 1951.

From columns 3 to 5 estimates are based on placebo cutoffs.[40] Column 3 uses as a placebo cutoff period the year 1885. In other words, the post dummy takes value one over the year 1885 and until 1921, as indicated in the column heading. Column 4 considers as a placebo year 1901. Columns 5 and 6 use 1881 and 1871 as a placebo cutoffs, respectively. Note that the coefficient in column 5 is negative and statistically significant, which may be due to the change in the frequency of the data given that no population census was conducted in 1891.

This section illustrated that areas more exposed to the BG experienced a cumulative process of development that stimulated industrialization and population growth. Such an effect emerged only after the introduction of the policy. In addition, it persisted after the repeal of the policy and until today. The results shown in this section are robust to a host of potentially confounding factors. For instance, in appendix section B.4, I take into account land inequality as it can influence human capital accumulation (Galor et al., 2009), as well as potentially unobserved differences between distant municipalities, and spatial spillovers (appendix section B.2). Of course, the BG was not the only policy interventions undertaken on the Italian territory from 1925 until today. I show that spatially biased policy interventions adopted during the period of the BG — such as land reclamation, infrastructure investments and internal migration policy — do no confound the estimates (appendix section B.4). Furthermore, it has been shown that areas more

[40] Population censuses were not conducted precisely every 10 years and the were not held at all in some years (1891 and 1941), entailing a frequency of the data that is not constant.

Table 4: Baseline Estimates: Placebo Cutoffs

Dependent Variable: *Ln Population Density*						
	Relevant Cutoff		*Placebo Cutoffs*			
	(1)	(2)	(3)	(4)	(5)	(6)
	1861 - 2011	1911 - 1951	1881 - 1921	1871 - 1921	1871 - 1921	1861 - 1901
	Post:1925	Post:1925	Post:1911	Post:1901	Post:1881	Post:1871
$\Delta lnPRI_{(1919-29)} \times Post$	0.1001***	0.0276***	0.0041	-0.0114	-0.0186**	-0.0121
	[0.022]	[0.010]	[0.007]	[0.009]	[0.008]	[0.008]
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Geography Flexible	Yes	Yes	Yes	Yes	Yes	Yes
Observations	95,657	32,368	24,763	30,919	30,919	23,688
Adjusted R-squared	0.919	0.974	0.983	0.979	0.979	0.981

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values as indicated in columns headings. Columns 3 to 6 display estimates based on placebo cutoffs. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

exposed to the WWII bombings and the reconstruction investment associated with the Marshall plan did not exhibit differences in agricultural production or technology during the period of the BG (Bianchi and Giorcelli, 2018), in turn minimizing concerns on the potantially confounding effect of these subsequent historical events. However, in the empirical analysis of the long-term consequences of policy interventions, the estimates should be interpreted as incorporating the potentially endogenous future policy response of national or local institutions (on this point, see Kline and Moretti (2014a)).

Taken together, the evidence indicates that areas which benefited from the policy acquired an advantage that unfolded during the period of industrialization, persisting until the present day. In the following, I advance the hypothesis that human capital played a key role in explaining the effect of the BG on economic development.

6 Human Capital as a Channel of Persistence

The importance of human capital in agricultural production has been studied at least since Griliches (1963a,b, 1964). Moreover, the importance of the complementarity between human capital and technical change was first underlined by Nelson and Phelps

(1966).[41] In their influential study, they observe that farmers with higher levels of education adopt new agricultural innovations more rapidly. The idea is that education increases farmers' ability to understand and evaluate new inputs and techniques. Thus, education becomes increasingly important in a fast changing environment in which there is a flow of new agricultural technologies. In other words, technical change increases the returns to human capital due to its relevance to the adoption of the new technologies that are constantly introduced. Building on this view, Foster and Rosenzweig (1996) advance the hypothesis that the technical change during the Indian Green Revolution increased the returns to education and stimulated human capital accumulation. I conjugate this view in the context of the BG to explain its persistent positive effects.

I hypothesize that the significant technological progress resulting from the BG increased the returns to education and stimulated human capital accumulation, which was conducive to industrialization and economic growth.[42,43] I investigate this hypothesis examining whether the BG had positive effects on education.[44] I find supporting evidence using variation *(i)* across cohorts within municipalities and *(ii)* across municipalities over time.

6.1 Cross-Cohort Analysis

If the policy had the hypothesized positive effect on human capital accumulation, such an effect would be stronger for individuals who were still in school when the policy was implemented. Therefore, the gap in educational attainment between cohorts that were at school age in 1925 and older cohorts should be larger in areas more exposed to the policy. In the following, I investigate this hypothesis. Then I complement the analysis, examining whether cohorts more exposed to the policy are more likely to be

[41] On the importance of the complementarity between technology and human capital in the process of economic development, see Goldin and Katz (1998); Galor (2005); Franck and Galor (2015).

[42] The increase in child labor observed over the period of the BG (Toniolo and Vecchi, 2007) may suggest that the increase in human capital accumulation caused by the BG operated on the intensive margin rather than through a labor-saving technical channel.

[43] The ability to adopt new innovation may come from agriculture-specific education which, in fact, surged over the period of the BG (Hazan, 1933). However, general education would still be crucial for at least two reasons. First, it increases the ability of the farmer to find the combination of inputs that is most appropriate in light of the specific geo-climatic conditions in which the farm operates (Huffman, 2001)— a concept similar to that of technology "appropriateness" (Basu and Weil, 1998). Second, education enhances managerial ability. In particular, when technical progress extends the set of production inputs (Romer, 1987, 1990), it increases managerial complexity and stimulates the returns to managerial human capital (Rosenzweig, 1980; Yang and An, 2002).

[44] My hypothesis is further supported by Dall Schmidt et al. (2018)'s finding of the effect of clover adoption across 17th century Danish market towns on the prevalence of folk high schools.

employed in manufacturing.

The Population Census of 1971 provides data on educational attainment across age groups and gender.[45] The data are aggregated in six age groups. Table 5 illustrates the structure of the data. The first column shows the 1971 age range of each group, while the second shows the range of the year of birth. The third column illustrates the age range for each group in 1925, the year in which the BG was implemented. The last column displays the number assigned to each group. I order the groups from 1 to 6, where group 1 is the oldest.

Table 5: The Cohorts Structure in the 1971 Census

Age in 1971	Year born	Age in 1925	Cohorts Group
≥65	≤1906	≥19	1
60-64	1907-1911	14-18	2
55-59	1912-1916	9-13	3
30-54	1917-1941	≤8	4
21-29	1942-1950	n.b.	5
14-20	1951-1957	n.b.	6

Notes: This table shows the cohorts structure in the Population Census of 1971. The age-group data are available aggregated in six groups. Educational attainment data are also available by gender. Groups 3 and 4 were more likely to be in school in 1925, when the policy was implemented. Groups 5 and 6 were not yet born at the time of the policy and are indicated with n.b.

While groups 3 and 4 were at school age when the policy was implemented, groups 1 and 2 were older and thus characterized by a smaller share of people in school. Groups 5 and 6 were yet to be born in 1925. I investigate whether there is a gap between school age groups (age groups 3 and 4) and older groups (1 and 2) by estimating the following model:

$$Y_{i,g} = \alpha_i + \alpha_{cg} + \beta_g \Delta lnPRI_{(1919-29),i} + \theta_g \mathbf{X} + \varepsilon_{ig} \tag{7}$$

where $Y_{i,g}$ is an outcome variable in municipality i, in age group g. For the human capital analysis, observations are by municipality, age group, and gender. Then, α_i represents municipality fixed effects, α_{cg} is province by age-group fixed-effect, β_g is the set of flexible estimates obtained from interacting growth in the *PRI* with age-group dummies, **X** is a set of controls interacted with age-group dummies, which includes land suitability for wheat, standard deviation of elevation, land suitability for agriculture, and historical presence of malaria. For the analysis on human capital, I also include gender by time fixed effects.

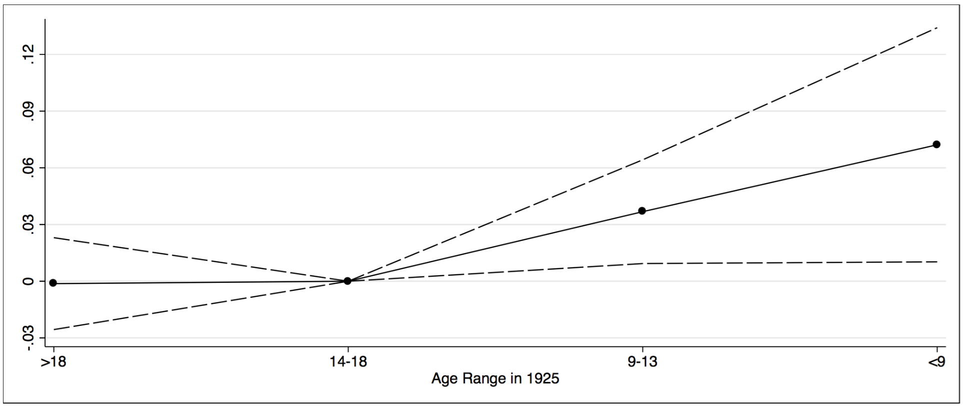
[45] Gender-level observations are only available for educational attainment. I employ these variation in appendix section B.6 to investigate heterogeneous effects of the policy across genders.

6.1.1 Human Capital across Cohorts

I measure human capital using average years of education. Following Barro and Lee (1993), I consider the population aged 25 or older and exclude groups 5 and 6 (see table 5). The hypothesis is that groups 3 and 4 should be more educated than groups 1 and 2, in the municipalities more exposed to the policy. Note that also in groups 1 and 2 there may be people still enrolled in school in 1925 that may have been affected by the policy in choosing their investment in education. This effect would actually reduce the magnitude of the estimated coefficients.[46]

The estimates of the flexible specification are depicted in figure 8 and illustrated in table A7. Consistent with the hypothesis advanced, in municipalities more exposed to the policy there was an increase in the average educational attainment precisely for those cohorts that were at school age when the policy was implemented. In particular, the estimated coefficients are statistically significant for cohorts aged between 9 and 13 versus those aged between 14 and 18.[47]

Figure 8: The *Battle for Grain* and Human Capital across Cohorts: Flexible Estimates



Notes: This figure depicts the coefficient estimates of (7) for the effect of the growth in the Potential Revenue Index on the average years of education across cohorts, and 95% confidence intervals based on province-level clustered standard errors. Observations are at the level of cohort-groups by gender in each municipality. Estimates are from a regression that include municipality fixed effects, province by cohort-group fixed effects, gender by time fixed effects, and flexibly controls for land suitability for wheat, land suitability for agriculture (CSI), terrain ruggedness, and historical presence of malaria. See the main text and appendices for variable definition and sources.

In the following, I examine whether the analysis across cohorts confirms the results shown above on the effect of the policy on industrialization.

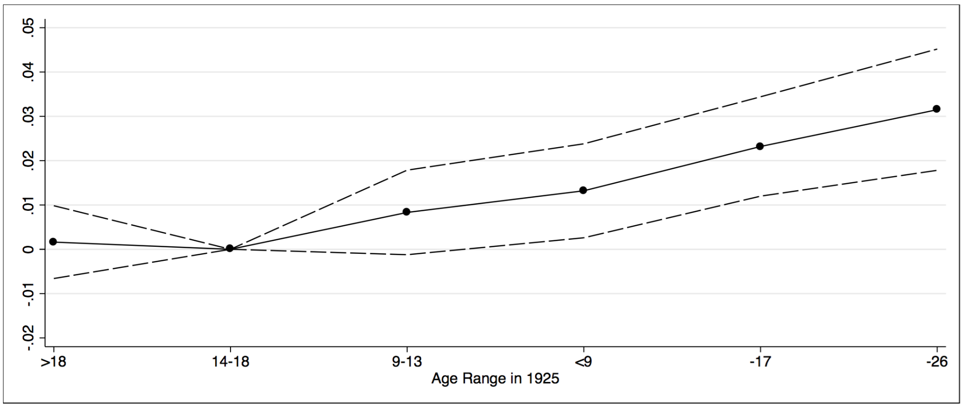
[46] In the following, I employ variation across municipalities over time to get an estimate of the magnitude of the effect of the policy on education.

[47] Over the period of the BG, education was compulsory for children up to 14 years of age.

6.1.2 Structural Transformation across Cohorts

Figure 9 illustrates the flexible estimates using as an outcome variable the employment share of manufacturing. In this case it is appropriate to use data on manufacturing employment within younger cohorts as it is informative of the degree of industrialization. The findings across cohorts confirm those across municipalities over time. In other words, in municipalities more exposed to the policy, age groups that had yet to reach working age during the BG had a significantly larger share of manufacturing workers. In turn, this finding suggests that municipalities more exposed to the policy experienced faster growth in the manufacturing sector. The effect emerged precisely for the cohorts that reached working age during the BG. Furthermore, the effect persists for groups 5 and 6, namely for people born after the end of the policy.

Figure 9: The *Battle for Grain* and Industrialization across Cohorts: Flexible Estimates



Notes: This figure depicts the coefficient estimates of (7) for the effect of growth in the growth in the Potential Revenue Index on the share of manufacturing population, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that includes municipality fixed effects, province by cohort-group fixed effects, and flexibly controls for land suitability for wheat, land suitability for agriculture (CSI), terrain ruggedness, and historical presence of malaria. See the main text and appendices for variable definition and sources.

Table 6 illustrates the estimates across age groups from a regression of education and employment shares by sector on the measure of exposure to the policy interacted with an indicator that takes value one if the cohort was school-aged (i.e. younger than 14) when the policy was implemented. Column 1 shows the result using the average years of education as an outcome. Column 2 illustrates the estimated coefficient using manufacturing employment share as an outcome. Consistent with the hypothesis, the coefficient estimates in columns 1 and 2 are positive and statistically significant, suggesting that the policy stimulated human capital accumulation and industrialization. Column 3 employs as an outcome the agricultural employment share. The negative coefficient in column 3 is consistent with the hypothesized effect of the BG on the speed of the transition out of agriculture. Finally, column 4 uses as an outcome variable the

Table 6: The *Battle for Grain*, Education, and Industrialization Across Cohorts

	Dependent Variable:			
	(1)	(2)	(3)	(4)
	Avg. Years Education	Empl. Share in Manufacturing	Empl. Share in Agriculture	Empl. Share in Others
$\Delta lnPRI_{(1919-29)} \times I_{age<14}$	0.0552**	0.0181***	-0.0183***	0.0002
	[0.022]	[0.005]	[0.006]	[0.006]
Observations	54,275	40,565	40,565	40,565
Adjusted R-squared	0.902	0.840	0.812	0.543
Province-Cohorts Group FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Geography Flexible Controls	Yes	Yes	Yes	Yes

Notes: Observations are at the level of municipality-cohort. This table illustrates that the exposure to the *Battle for Grain* positively affected average education for school-aged cohorts as of 1925 (column 1). The table also shows the positive effect on the transition to industry (column 2) and the negative effect on share of labor in agriculture (column 3). The sector "Others" includes services, commerce, transport, communications, finance, and public administration. The variable $I_{age<14}$ is a binary variable that takes value one if the cohort group is younger than 14 in 1925. In addition to indicating control variables and fixed-effects, regression in column 1 also includes gender by time fixed effects (gender data not available for the industry census in columns 2-4). Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

employment share in all the other sectors.[48] The estimated coefficient is not statistically different from zero. The absence of a local persistent effect of the policy on the service sector across age groups can be rationalized by the presence of absentee landowners (Fujita, 1989) whose consumption does not take place locally. Thus, even enhancing the service sector at the country level, it would not be captured by the difference-in-differences specification. Taken together, table 6 suggests that the policy stimulated local accumulation human capital and was conducive to an acceleration of the exodus from agriculture towards manufacturing.

In this section, I have shown that cohorts at school age at the time of the policy experienced a more rapid increase in educational attainment in municipalities more exposed to the BG. The cross-cohorts estimates also confirm the findings of the effect of the policy on industrialization. Below, to get a sense of the magnitudes of the effects of the policy on human capital, I employ educational attainment data across municipalities over time.

[48] This residual category includes services, commerce, transport, communications, finance, and public administration. Data on employment shares in each individual sector are not available.

6.2 Human Capital across Municipalities

In this section, I study the effect of the BG on human capital across municipalities over time. As outcome variables, I use two measures of education. First, given that elementary school was compulsory and only 2.5% of the population attained a level higher than the middle school, I use the share of people aged 14 or older with at least a middle school certificate in 1951. Second, I use the average years of education in 1951 and 1971, converted from education attainment levels by using duration of each level. I control for education before the policy using data on literacy rates in 1921, the only data available for that period.[49] However, given that literacy may be an imperfect control for pre-policy education level, I also control for a large set of geographic and socioeconomic characteristics, and for province fixed effects.

The estimated model is given by

$$Y_i = \alpha_c + \beta \Delta lnPRI_{(1919-29),i} + \beta_2^{'} \boldsymbol{X} + \varepsilon_i \tag{8}$$

where Y_i represents economic outcomes of municipality i, $\boldsymbol{X}$ is a vector of time-invariant control variables and pre-policy socioeconomic controls for municipality i, α_c is a province fixed effect, and ε_i is the error term for municipality i.

Even in this specification, I control for land suitability for wheat and the Caloric Suitability Index. In addition, I control for latitude, median elevation, standard deviation of elevation,[50] and the elevation range (the log of the differences between maximum and minimum elevation within the municipality), as well as the historical presence of malaria. Exposure to the policy may be correlated with proximity to big markets and to water trade routes, which can independently affect the process of industrialization and economic prosperity. Therefore, I control for distance to water (minimum distance from the coastline and major rivers) and minimum distance to the most populous cities as of 1921 (Milan, Naples, Palermo, Rome, and Turin). To further control for potential preexisting differences, I control for population density in 1921 in logs, thus only four years before the introduction of the BG, the standard measure of market access by Harris (1954), measured by the log of the average population in neighboring municipalities weighted by distance, and the density of ancient Roman roads.[51]

[49] Including nonlinear effects of literacy as controls in seeking to take into account of preexisting educational attainment patterns improves the estimates.

[50] Alternative controls such as standard deviation within 10 or 20 kilometers radius do not affect the results.

[51] On the importance or Roman roads for economic prosperity, see Dalgaard et al. (2018).

Table 7 shows that the growth in the PRI has a positive and significant effect on education. Consistent with the hypothesis advanced, column 1 shows that the potential returns from the BG has a positive and significant effect on the share of the population with at least a middle school certificate. Column 2 shows that the coefficient of interest increases in magnitude after controlling for literacy before the policy, which suggests that preexisting levels of education are negatively correlated with my measure of the BG. Columns 3 and 4 illustrate the same estimates using as an outcome the average years of education in 1951. The estimated coefficient is positive and significant. Again the coefficient increases in magnitude when literacy before the policy is taken into account. Columns from 1 to 4 show that the exposure to the policy was conducive for human capital accumulation already in 1951. In columns 5 and 6, I use as an outcome the average years of education in 1971. Even with this measure of education the estimates are positive and significant and show an increase in magnitude when pre-policy literacy is taken into account. Interestingly, the magnitude of the estimated coefficients is smaller in column 6 with respect to column 4. This suggests that migration patterns across municipalities from 1951 to 1971 do not reinforce the estimated effect of the BG on education, lending credence to the identification assumption of the cross-cohorts analysis in section 6.1. Finally, column 7 performs a placebo check where I use the literacy rate in 1921 as an outcome. Reassuringly, the estimated coefficient is negative and not significantly different from zero, suggesting that the effect of exposure to the BG is not capturing differences in human capital that were already present before the introduction of the policy. It is worth noting that the coefficient for land suitability for wheat is not statistically different from zero across all specifications, which points toward the fact that, although the BG was beneficial for wheat-suitable areas, its positive local effect on human capital unfolded mainly through technological improvements. In the following, I will further investigate this hypothesis.

In addition to the stimulus to average education, the higher returns from adopting the new technologies may have stimulated investment in technical human capital. Using census data on the share of high school graduates across municipalities, I investigate this aspect in table 8.

The first column of table 8 shows that areas more exposed to the policy were characterized by a larger share of technical high schools graduates. Column 2 shows that using the share of teacher training high school graduates as an outcome the coefficient estimate is not statistically different from zero. Similarly, using the share other high school graduates as an outcome, the estimated coefficients are either statistically indistinguishable from zero or negative. These findings strongly support the hypothesis of

Table 7: The *Battle for Grain* and Human Capital across Municipalities

	(1) Share Middle School 1951	(2) Share Middle School 1951	(3) Avg. Yrs of Educ. 1951	(4) Avg. Yrs of Educ. 1951	(5) Avg. Yrs of Educ. 1971	(6) Avg. Yrs of Educ. 1971	(7) Literacy 1921
$\Delta lnPRI_{(1919-29)}$	0.0895**	0.0907**	0.0928**	0.0938**	0.0773**	0.0780**	-0.0027
	[0.044]	[0.045]	[0.037]	[0.038]	[0.035]	[0.035]	[0.019]
Wheat Suit.	0.0072	0.0030	0.0018	-0.0015	-0.0079	-0.0111	0.0112
	[0.023]	[0.022]	[0.024]	[0.023]	[0.022]	[0.022]	[0.013]
Literacy 1921		0.3728***		0.2894***		0.2891***	
		[0.035]		[0.033]		[0.039]	
province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to water and cities	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre Policy Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,165	6,165	6,165	6,165	6,181	6,181	6,192
Adj. R^2	0.333	0.357	0.310	0.325	0.407	0.422	0.820

Notes: This table illustrates estimates of the effect of the exposure to the *Battle for Grain* on education across municipalities. Observations are at municipality level. Outcome variables are denoted in column headings. All variables are standardized. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

the importance of the complementarity between agricultural technologies and technical skills, lending credence to the hypothesis of the importance of human capital accumulation in explaining the estimated effects of the BG on long-run development.

Table 8: The *Battle for Grain* and Human Capital Composition across Municipalites

Dependent Variable: Share of High School Graduates in 1951 by Major				
		Placebo		
	(1)	(2)	(3)	(4)
VARIABLES	Technical School	Teacher Training	Classical or Scientific	Others or Unspecified
$\Delta lnPRI_{(1919-29)}$	0.0739**	-0.0690	-0.0005	-0.0416*
	[0.034]	[0.045]	[0.049]	[0.024]
Wheat and Agricultural Suitability	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes
Distance to water and cities	Yes	Yes	Yes	Yes
Pre Policy Controls	Yes	Yes	Yes	Yes
Observations	6,393	6,393	6,393	6,393
Adj. R^2	0.371	0.195	0.156	0.0632

Notes: This table illustrates estimates of the effect of the exposure to the *Battle for Grain* on human capital composition across municipalities. Observations are at municipality level. Outcome variables are denoted in column headings and refer to the share of the population with a high school degree in each field. The residual category "Other Schools" includes other minor as well as unspecified categories All variables are standardized. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

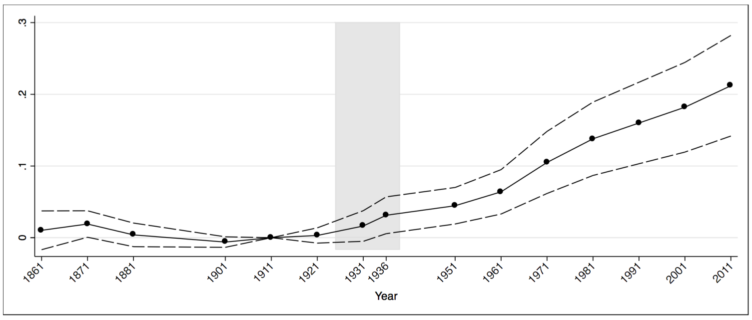
6.2.1 Technology versus Price Effect

The BG combined agricultural technical change with protection. This section investigates whether the estimated positive effect of the BG on education is driven mainly by agricultural technical change or by the wheat price shock. In particular, I split my measure of the potential returns from the policy in its part due to technical change and its part due to the increase in the relative wheat price so as to disentangle one effect from the other. Table 9 illustrates the results.

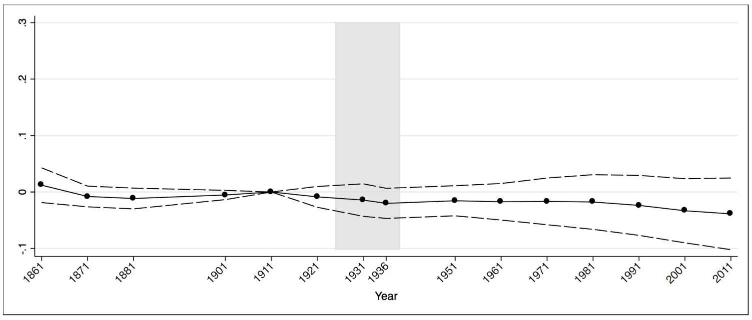
As evident from the table, while municipalities more exposed to the technological progress resulting from the BG experienced an increase in education that persisted until 1951 and 1971, those more exposed to the local effect of the increase in the national wheat price did not. This result confirms the hypothesis that the positive effect of the BG on human capital accumulation functioned through technical change, rather than an increase in wheat prices and the associated income effect. Indeed, areas that benefited

Figure 10: Technology versus Price effect and Population Density

(a) Technology and Population Density



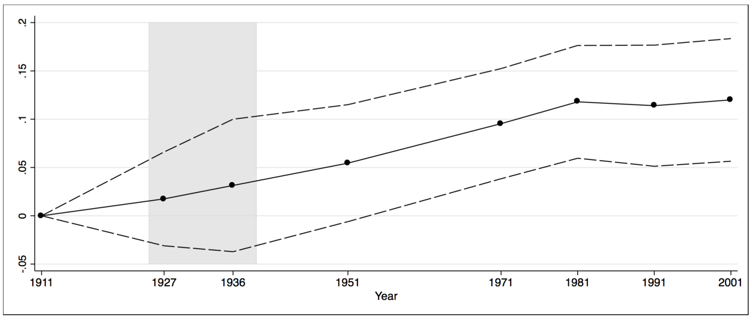
(b) Price Effect and Population Density



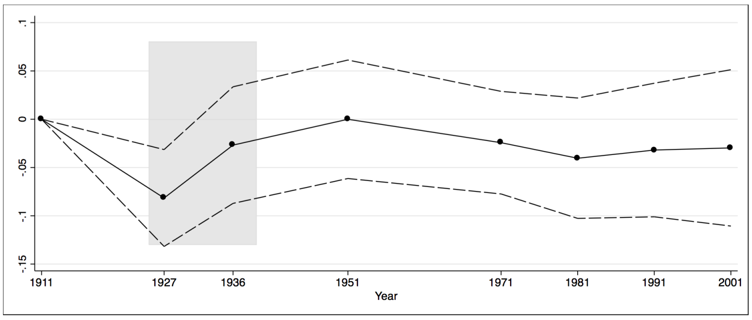
Notes: The above figures depict the coefficient estimates of (5) for the effect of growth in the Potential Revenue Index due to technical change (panel (a)) and price change on population density measured in natural logarithms. The regression includes both indexes (interacted with year indicators), municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). No Population Census was conducted in 1891 or 1941. See the main text and appendices for variable definition and sources.

Figure 11: Technology versus Price effect and Industrialization

(a) Skill-Biased Agricultural Technical Change and Industrialization



(b) Price Effect and Industrialization



Notes: The above figures depict the coefficient estimates of (5) for the effect of growth in the Potential Revenue Index due to technical change (panel (a)) and price change on the share of people in manufacturing. The regression includes both indexes (interacted with year indicators), municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). No Population Census was conducted in 1891 or 1941. See the main text and appendices for variable definition and sources.

Table 9: Technology versus Price effect and Human Capital

	(1) Share Middle School 1951	(2) Avg. Yrs of Educ. 1951	(3) Avg. Yrs of Educ. 1971
$\Delta lnPRI_{(1919-29)}Technology$	0.0981**	0.1035***	0.0817**
	[0.044]	[0.039]	[0.035]
$\Delta lnPRI_{(1919-29)}Prices$	-0.0342	-0.0437*	-0.0187
	[0.026]	[0.025]	[0.022]
Wheat Suit.	0.0009	-0.0040	-0.0124
	[0.021]	[0.023]	[0.022]
Literacy 1921	Yes	Yes	Yes
province FE	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes
Distance to water and cities	Yes	Yes	Yes
Pre Policy Controls	Yes	Yes	Yes
Observations	6,165	6,165	6,181
Adj. R^2	0.358	0.325	0.422

Notes: This table establishes the importance of the agricultural technical change due to the BG in stimulating education. Observations are at municipality level. Human capital variables are denoted in column headings. Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

from the policy through the increase in the relative price of wheat, rather than technology adoption, did not experience a significant increase in education. If anything, the sign of the coefficient is negative, albeit statistically insignificant. This result further supports the hypothesized skill-biased nature of the technical change resulting from the BG.

Having established the relevance of technical change in explaining the effect of the BG on human capital, I investigate its importance for development and industrialization. I employ a flexible specification, as equation (5) in section 5.2.2, in which I include the index of technical change and that of the price change. Figures 10 and 11 show the estimated effects of technical change and price change on population density and industrialization, respectively. The positive effect of technology and the limited effects of the increase in prices on economic development further confirm the finding for human capital. Interestingly, as depicted in the bottom panel of figure 11, the short run effect of the price shock on industrial development is negative and significant. Then, it dissipates over time. This finding may be interpreted as a negative short-run effect of the rise in the returns to factors in agriculture, as brought about by the wheat tariff, and suggest that, while transitory protection may spur technological progress and long-term development, its negative effects on non-protected sectors may not be long-lasting.

Taken together, the results of this section show that the positive shock to technological progress in agriculture resulting from the BG stimulated human capital accumulation. Instead, the increase in wheat price had limited effects on human capital accumulation, which is consistent with the literature emphasizing that a Hicks-neutral increase in agricultural productivity and the associated increase in the returns to factors in agriculture may lead to specialization in this sector, ultimately hampering human capital accumulation (Galor and Mountford, 2008) and the transition to industry (Matsuyama, 1992; Bustos et al., 2016).

7 Concluding Remarks

This paper studies the BG to find that agricultural development policies may have positive persistent effects on local economic activity. The heterogeneous exposure across Italian municipalities to the different interventions that compose the BG represents a unique opportunity to investigate the mechanisms through which agricultural policy may affect industrialization and economic development in the long term. The finding that the local effect of the policy is explained by technological progress and its positive effects on human capital accumulation, rather than the tariff-induced increase in the wheat price, can inform the literature on the consequences and functioning of policy intervention for structural transformation.

Exploring the country-level effect of the policy lies beyond the scope of this work. Such an analysis would require a different data set and identification strategy and is left to future research. Yet, the finding that short-term agricultural policy interventions can have long-lasting effects on local economic activity offers hope that future research will cast further light on the consequences of policy, providing insights into long-term unfolding of the development process.

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Supplementary Material to "Agricultural Policy and Long-Run Development: Evidence from Mussolini's *Battle for Grain*"

Mario F. Carillo*

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Abstract

The Supplementary Appendix reports (i) additional tables (ii) additional results and robustness (iii) supplementary figures (iv) detailed data description

*Department of Economics and Statistics, University of Naples Federico II. Email: MarioFCarillo@gmail.com

Appendices

A Supplementary Tables

Table A1: Increase in Wheat Yield and Economic Development: Flexible Estimates

	(1) Ln Population Density	(2) Manufacturing Pop. Share
$\Delta q^{w}_{23-29} \times 1861$	-0.0028	
	[0.010]	
$\Delta q^{w}_{23-29} \times 1871$	-0.0011	
	[0.006]	
$\Delta q^{w}_{23-29} \times 1881$	-0.0113**	
	[0.005]	
$\Delta q^{w}_{23-29} \times 1901$	-0.0017	
	[0.003]	
$\Delta q^{w}_{23-29} \times 1911$	0	0
$\Delta q^{w}_{23-29} \times 1921$	0.0032	
	[0.003]	
$\Delta q^{w}_{23-29} \times 1927$		0.0108
		[0.017]
$\Delta q^{w}_{23-29} \times 1931$	0.0022	
	[0.006]	
$\Delta q^{w}_{23-29} \times 1936$	0.0125*	0.0076
	[0.007]	[0.019]
$\Delta q^{w}_{23-29} \times 1951$	0.0258***	0.0393*
	[0.008]	[0.023]
$\Delta q^{w}_{23-29} \times 1961$	0.0417***	
	[0.011]	
$\Delta q^{w}_{23-29} \times 1971$	0.0671***	0.0515*
	[0.016]	[0.027]
$\Delta q^{w}_{23-29} \times 1981$	0.0877***	0.0773***
	[0.021]	[0.028]
$\Delta q^{w}_{23-29} \times 1991$	0.1053***	0.0870***
	[0.024]	[0.029]
$\Delta q^{w}_{23-29} \times 2001$	0.1169***	0.0846***
	[0.027]	[0.030]
$\Delta q^{w}_{23-29} \times 2011$	0.1338***	
	[0.031]	
Municipality FE	Yes	Yes
province × Year FE	Yes	Yes
Observations	95,293	50,308
Adjusted R-squared	0.915	0.599
P-value for Joint Significance $t \geq 1925$	0	0.0325

Notes: This table shows flexible estimates from regressing the (standardized value of the) increase in wheat yield over the years 1923-1929 interacted with decade indicators on (columns 1) the natural logarithm of population density, and on the share of the population employed in manufacturing (columns 2). Observations are at the municipality-year level. All regressions include municipality fixed effects, and province-year fixed effects. Robust standard errors clustered at the province level in brackets. *** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A2: The Battle for Grain and Long-run Economic Development: Flexible Specification

	(1) Ln Population	(2) Ln Population	(3) Employment Manufacturing	(4) Employment Manufacturing
$\Delta lnPRI_{(1919-29)} \times 1861$	0.0097	0.0117		
	[0.013]	[0.014]		
$\Delta lnPRI_{(1919-29)} \times 1871$	0.0109	0.0181*		
	[0.010]	[0.010]		
$\Delta lnPRI_{(1919-29)} \times 1881$	-0.0076	0.0020		
	[0.009]	[0.009]		
$\Delta lnPRI_{(1919-29)} \times 1901$	-0.0087**	-0.0071*		
	[0.004]	[0.004]		
$\Delta lnPRI_{(1919-29)} \times 1911$	0	0	0	0
$\Delta lnPRI_{(1919-29)} \times 1921$	0.0048	0.0018		
	[0.004]	[0.005]		
$\Delta lnPRI_{(1919-29)} \times 1927$			0.0061	0.0071
			[0.025]	[0.027]
$\Delta lnPRI_{(1919-29)} \times 1931$	0.0191*	0.0145		
	[0.011]	[0.011]		
$\Delta lnPRI_{(1919-29)} \times 1936$	0.0352***	0.0288**	0.0099	0.0267
	[0.013]	[0.013]	[0.040]	[0.037]
$\Delta lnPRI_{(1919-29)} \times 1951$	0.0512***	0.0431***	0.0400	0.0555*
	[0.013]	[0.013]	[0.032]	[0.029]
$\Delta lnPRI_{(1919-29)} \times 1961$	0.0701***	0.0624***		
	[0.017]	[0.016]		
$\Delta lnPRI_{(1919-29)} \times 1971$	0.1135***	0.1038***	0.0960***	0.0933***
	[0.023]	[0.023]	[0.032]	[0.030]
$\Delta lnPRI_{(1919-29)} \times 1981$	0.1506***	0.1377***	0.1321***	0.1128***
	[0.027]	[0.027]	[0.037]	[0.031]
$\Delta lnPRI_{(1919-29)} \times 1991$	0.1760***	0.1588***	0.1311***	0.1101***
	[0.029]	[0.030]	[0.038]	[0.033]
$\Delta lnPRI_{(1919-29)} \times 2001$	0.2000***	0.1803***	0.1433***	0.1176***
	[0.032]	[0.033]	[0.041]	[0.034]
$\Delta lnPRI_{(1919-29)} \times 2011$	0.2326***	0.2097***		
	[0.035]	[0.037]		
Municipality FE	Yes	Yes	Yes	Yes
province × Year FE	Yes	Yes	Yes	Yes
Wheat Suitability	Yes	Yes	Yes	Yes
Geographic Controls	No	Yes	No	Yes
Observations	95,657	95,657	50,547	50,547
Adjusted R-squared	0.919	0.920	0.607	0.608
P-value for Joint Significance $t \geq 1925$	0	0	0.0045	0.0058

Notes: This table shows flexible estimates of the effect of the *Battle for Grain* on population density (columns 1 and 2), and on the share of the population employed in manufacturing (columns 3 and 4). Observations are at the municipality-year level. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A3: Baseline Specification - Population Growth Rates

	(1)	(2)	(3)	(4)
Dependent Variable: *Ln Population Density*				
$\Delta lnPRI_{(1919-29)} \times Post \times t$	0.0284***	0.0286***	0.0275***	0.0277***
	[0.005]	[0.005]	[0.005]	[0.005]
Wheat Suitability	Yes	Yes	Yes	Yes
Agric. Suitab.	No	Yes	Yes	Yes
Ruggedness	No	No	Yes	Yes
Hist. Malaria	No	No	No	Yes
Observations	95,657	95,657	95,657	95,657
Adjusted R-squared	0.919	0.920	0.920	0.920

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values larger or equal to 1925. All regressions include the term $\Delta lnPRI_{(1919-29)} \times Post$, municipality fixed effects, and province-year fixed effects. Each control variable is interacted with year indicators. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A4: Baseline Specification - Manufacturing Growth Rates: Estimates

	(1)	(2)	(3)	(4)
Dependent Variable: Share of Population in Manufacturing				
$\Delta lnPRI_{(1919-29)} \times Post \times t$	0.0021***	0.0021***	0.0017***	0.0016***
	[0.001]	[0.001]	[0.001]	[0.001]
Wheat Suitability	Yes	Yes	Yes	Yes
Agric. Suitab.	No	Yes	Yes	Yes
Ruggedness	No	No	Yes	Yes
Hist. Malaria	No	No	No	Yes
Observations	50,547	50,547	50,547	50,547
Adjusted R-squared	0.607	0.607	0.608	0.608

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values larger or equal to 1925. All regressions include the term $\Delta lnPRI_{(1919-29)} \times Post$, municipality fixed effects, and province-year fixed effects. Each control variable is interacted with year indicators. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A5: The Exposure to the *Battle for Grain* and Population Growth

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Δ Ln Population 1921-2011						
$\Delta lnPRI_{(1919-29)}$	0.1857***	0.3675***	0.2288***	0.2325***	0.2071***	0.2103***
	[0.009]	[0.032]	[0.034]	[0.034]	[0.035]	[0.036]
Observations	6,441	6,441	6,441	6,441	6,441	6,441
Province FE	No	Yes	Yes	Yes	Yes	Yes
Wheat Suitability	No	No	Yes	Yes	Yes	Yes
Agric. Suitability	No	No	No	Yes	Yes	Yes
Ruggedness	No	No	No	No	Yes	Yes
Hist. Malaria	No	No	No	No	No	Yes
Adj. R^2	0.0557	0.365	0.401	0.404	0.407	0.407
R^2 Within	-	0.100	0.150	0.155	0.159	0.160

Notes: This table shows that the link between the returns from the *Battle for Grain* ($\Delta lnPRI$) and population growth between 1921 and 2011, controlling for wheat suitability, province-fixed effects, and other controls. Robust standard errors clustered at the province level in brackets. Observations are at the municipality level. See the main text and appendices for definitions of variables and sources.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A6: The Exposure to the *Battle for Grain* and Industrialization

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Δ Share Manufacturing Population 1911-2011						
$\Delta lnPRI_{(1919-29)}$	0.2765***	0.2351***	0.1285***	0.1281***	0.1044***	0.1034***
	[0.011]	[0.035]	[0.033]	[0.033]	[0.031]	[0.030]
Observations	5,542	5,542	5,542	5,542	5,542	5,542
Province FE	No	Yes	Yes	Yes	Yes	Yes
Wheat Suitability	No	No	Yes	Yes	Yes	Yes
Agric. Suitability	No	No	No	Yes	Yes	Yes
Ruggedness	No	No	No	No	Yes	Yes
Hist. Malaria	No	No	No	No	No	Yes
Adj. R^2	0.0784	0.183	0.196	0.195	0.197	0.197
R^2 Within	-	0.0207	0.0360	0.0361	0.0376	0.0377

Notes: This table shows that the link between the returns from the *Battle for Grain* ($\Delta lnPRI$) and the change in the share of the population employed in the manufacturing sector between 1911 and 2001, controlling for wheat suitability, province-fixed effects, and other controls. Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets. Observations are at the municipality level. See the main text and appendices for definitions of variables and sources.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table A7: The *Battle for Grain* and Human Capital Across Cohorts

	(1)	(2)	(3)	(4)
Dependent Variable: Avg. Years of Education				
$\Delta lnPRI_{(1919-29)} \times$ Group 1	-0.0030	-0.0022	-0.0045	-0.0013
	[0.012]	[0.012]	[0.013]	[0.012]
$\Delta lnPRI_{(1919-29)} \times$ Group 2	0	0	0	0
$\Delta lnPRI_{(1919-29)} \times$ Group 3	0.0416***	0.0417***	0.0393***	0.0368**
	[0.014]	[0.014]	[0.014]	[0.014]
$\Delta lnPRI_{(1919-29)} \times$ Group 4	0.0905***	0.0889**	0.0786**	0.0722**
	[0.034]	[0.034]	[0.033]	[0.032]
Wheat Suitability	Yes	Yes	Yes	Yes
Agric. Suitab.	No	Yes	Yes	Yes
Ruggedness	No	No	Yes	Yes
Hist. Malaria	No	No	No	Yes
Observations	54,275	54,275	54,275	54,275
Adjusted R-squared	0.902	0.902	0.902	0.902

Notes: Observations are at the level of municipality-age group-gender. This table illustrates that the exposure to the *Battle for Grain* positively affected average education for schooling-aged cohorts as of 1925 (Groups 3 and 4). Group 2 is the reference group. See table 5 for the structure of the cohort groups data. All regressions control for municipality fixed effects, province by time fixed effects, gender by time fixed effects. Robust standard errors clustered at the province level in brackets.

*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B Additional Results and Robustness

B.1 The PRI: Sources of Variation

To gain a better understanding of the source of variation of the PRI, I reconstruct the index using alternative specifications and investigate their correlation with the actual increase in wheat yield over the years of the policy. Results are depicted in table B1. Column 1 shows the baseline formulation of the PRI for comparison. Column 2 employs a version of the index where technology is constant at low level and only the change in prices is considered. Column 3 employs as a source of variation the index of interest where only the technological level improves, while prices are constant at the pre-policy level. A comparison of the first three columns shows that both the price shock and the technology shock are important determinants of the increase in wheat yield. Reassuringly, the baseline index of the growth in the PRI, where both sources of variation are used, is a better predictor of the actual increase in wheat yield due to the policy. Column 4 employs a version of the index where the set of crops at the denominator of the PRI includes also complementary crops. Column 5 uses the baseline crops, with the difference that the denominator of the PRI is given by the maximum revenues across non complementary crops, rather than the average. The last column employs, as a placebo, the PRI built with prices from 1901 to 1911, thus before World War I. Reassuringly, this placebo version of the index is not a good predictor of the change in wheat over the first years of the BG. This finding supports the validity of the index as a measure of the potential returns from the BG.

B.2 Spatial Analysis and Spillovers

Having investigated the source of time variation that is associated with the effect of the policy, I next turn to investigating its source of spatial variation. For this purpose, I employ my baseline specification shown above with the key differences that I restrict the spatial extent of the cluster on which I am taking the time-varying fixed-effects. In other words, while in the baseline specification estimates are based on variation within provinces, in the following I will use variation within squares of smaller and smaller size to understand the source of spatial variation that is driving the results.

Table B2 illustrates the estimated coefficients. Column 1 reports the results with province by time fixed-effects for comparison. Column 2 employs variation within squares of 25 squared kilometers (see maps in figure 14). Interestingly, the coefficient

Table B1: Understanding the PRI. OLS

	(1)	(2)	(3)	(4)	(5)	(6)
***Dependent Variable**: Δ Wheat Productivity 1923-1929*						
$\Delta lnPRI_{(1919-29)}$	0.3042***					
	[0.082]					
$\Delta lnPRI_{(1919-29)} Prices$		0.0835**				
		[0.038]				
$\Delta lnPRI_{(1919-29)} Technology$			0.2958***			
			[0.081]			
$\Delta lnPRI_{(1919-29)}$ All Crops				0.2938***		
				[0.082]		
$\Delta lnPRI_{(1919-29)}$ Max					0.3261***	
					[0.087]	
$\Delta lnPRI_{(1901-11)}$						-0.0077
						[0.043]
province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,662	6,662	6,662	6,662	6,662	6,662
Adjusted R^2	0.417	0.392	0.416	0.415	0.419	0.387

Notes: This table establishes that each of the sources of variation that compose the potential returns from the *Battle for Grain* is relevant in predicting the actual increase in wheat yield over the years of the *Battle for Grain* (columns 1 - 3). The table also establishes that the measure is not sensitive to the specific functional form (columns 4 and 5). Finally it is shows that using prices from a placebo period makes the index irrelevant. Observations are at the municipality level. See the main text and appendices for definitions of variables and sources. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

increases. A similar effect is observed when restricting the size of the cluster even further. The estimates suggest that potential unobservable characteristics would bias the coefficient toward zero, thus working against finding any effect of the policy.

The fact that the source of variation is so granular may rise concerns on spatial spillovers. For instance, municipalities more exposed to the policies may have triggered development in neighbor municipalities, in turn reducing the magnitude of the estimated coefficients. In order to examine this aspect, column 7 controls for the average growth in the PRI for all the neighboring municipalities weighted by distance. Albeit statistically insignificant, the coefficient estimate for the neighbors effect is negative. Furthermore, the coefficient of interest slightly increases in magnitude. This result suggests that, if spatial spillovers are present, they do not work against finding any effect of the policy.

Table B2: Baseline Estimates: Spatial Analysis and Spillovers

	Dependent Variable: *Ln Population Density*						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Grid	Grid	Grid	Grid	Grid	
	province	30 KM	25 KM	20 KM	15 KM	10 KM	province
$\Delta lnPRI_{(1919-29)} \times Post$	0.1005***	0.1326***	0.1598***	0.1621***	0.1557***	0.1610***	0.1012***
	[0.022]	[0.023]	[0.023]	[0.020]	[0.026]	[0.026]	[0.023]
$\Delta lnPRI_{(1919-29)} Nghb \times Post$							-0.0138
							[0.099]
Column heading by time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geography Flexible	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	95,657	95,216	95,191	94,423	92,444	81,648	95,633
Adjusted R-squared	0.919	0.933	0.937	0.940	0.943	0.948	0.919

Notes: This table shows baseline estimates using year by group fixed effects. Groups based on spatial location indicated by column headings. Column 1 shows estimates from the baseline specification using province by year fixed effects. Column 2 uses year by a group defined by the set of municipalities whose centroid falls in a square of $30km^2$. Other columns from 3 to 6 perform the same exercise restricting the size of the squares. Column 7 controls for the average potential returns from the *Battle for Grain* for all neighboring municipalities weighted by distance, and using province by year fixed-effects. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.3 Heterogeneous Effects

The evidence shown highlights the importance of agricultural technical change in stimulating the transition to industry and long-term development. To better understand how the effect of the policy unfolded, it is of interest to investigate how the rise in agricultural technology interacted with preexisting conditions. For this purpose, I interact my variable of interest with an indicator variable that takes value one based on pre-existing characteristics at the municipality level. Results are illustrated in table B3.

For instance, substantial differences in economic development across Italian regions were already present well before the Fascist regime, and the debate on the 'Southern Question' begun as early as the 70's of the nineteenth century. In order to examine whether the effect of the policy interacted with north-south patterns, column 1 interacts my measure of the potential returns from the BG with a dummy that takes value one if the municipality is in the South or Islands.[1] The estimated coefficient shows that the effect of the BG is more pronounced in these regions with respect to the Center-North. This finding can be explained by the fact that the South and Islands were more rural compared to other places, therefore they were potentially more exposed to the agricultural policy under study.

One potential concern is that the results are driven by regions of the country that are highly suitable for wheat, rather than by the technical change associated wit the BG. To consider this possibility, in column 2, I interact my variable of interest with a dummy that takes value one if wheat suitability is above the national median. Interestingly, the interaction is negative and statistically significant, thus mitigating this concern.

In section B.2, I have shown that the effect of the policy on population density is stronger when considering municipalities that are close to each other. Given that migration cost increases with distance, the movement of people across municipalities may be an important force in explaining this pattern of the estimates on population density. Unfortunately, data on migration are not available at this level of aggregation. Therefore, to shed light on this aspect, I consider heterogeneous effect of the policy based on whether a municipality experienced population growth above or below population growth at the national level. The idea is that places that exhibit population growth faster than the country population growth are presumably more exposed to in-migration. In column 3, I look at the interaction with a dummy that takes value one if population growth in the municipality over the years from 1921 to 2011 experienced population growth faster than the national one. The negative coefficient of the interaction term suggests that the effect is not necessarily driven by substantial in-migration but presumably by a reduction in out-migration.

Columns 4 and 5 investigate whether the estimated effect of the policy is driven by

[1] I follow the official definition from ISTAT.

large urban centers. In column 4, I look at the interaction with a dummy that takes value one if population density in 1921 is above the median. Column 5 illustrates the interaction with an indicator that takes value one if in 1929 more than half of the citizens live in centers.[2] The estimated coefficients are negative and statistically insignificant. Suggesting that the estimated effect is driven by smaller municipalities that are less urbanized and thus more likely to be exposed to agricultural policies.

Table B3: Heterogeneous Effects

Dependent Variable: *Ln Population Density*					
	(1) South and Islands	(2) High Wheat Suitab.	(3) Pop.Growth $\geq$ National	(4) High Pop. D.ty 1921	(5) Urban. Pop. 1931
$\Delta lnPRI_{(1919-29)} \times Dummy$ $\times Post$	0.1225***	-0.0749**	-0.0470*	-0.0382	-0.0236
	[0.045]	[0.030]	[0.026]	[0.023]	[0.025]
$\Delta lnPRI_{(1919-29)} \times Post$	0.0730***	0.1324***	0.0633***	0.0971***	0.1150***
	[0.024]	[0.024]	[0.018]	[0.022]	[0.022]
Observations	95,657	95,657	95,657	95,657	95,657
Adjusted R-squared	0.920	0.920	0.936	0.921	0.919

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one after 1925. The variable *Dummy* takes value one as indicated in column heading. In column 1, *Dummy* takes value one for municipalities that belong to South and Islands regions the country. In column 2, the variable *Dummy* takes value one if wheat suitability is above the median. In column 3, the variable *Dummy* takes value one if population growth over the years 1921-2001 is above the national one. In column 4, the variable *Dummy* takes value one if more a municipality is characterized by population density above the median. In column 5, the variable *Dummy* takes value one if in a municipality more than half of citizens live in centers. All regressions control for $\Delta lnPRI_{(1919-29)} \times Post$ as well as $Post \times Dummy$. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets. *** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.4 Other Policies and Mechanisms

Over the period of the BG, there were other interventions undertaken by the Fascist dictatorship. Such policies would be a threat to the proposed identification strategy if, in addition to effectively influence economic development, they interacted with the within-province variation in the measure of the potential returns from the BG. This section investigate whether there is evidence of a significant interaction between other interventions and the BG. Results are depicted in table B4.

An important policy undertaken over this period of time was the intervention of land reclamation of areas historically affected by malaria. Columns 1 and 2 examines

[2] Centers are defined in the Census of Agriculture 1929 as areas where groups of citizens live around a place of agglomeration such as a church, stores, schools and so on.

Table B4: Other Policies and Mechanisms

	Dependent Variable: Ln Population Density					
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Malaria 1870	New Towns	Railroad 1931	Pop. $\leq$25k in 1921	Gini Land Ineq. 1931	Avg Farm Size 1931
$\Delta lnPRI_{(1919-29)} \times Dummy$ $\times Post$	-0.0961***	0.0898	0.0057	-0.0598	-0.0160	-0.0044
	[0.029]	[0.054]	[0.019]	[0.048]	[0.022]	[0.022]
$\Delta lnPRI_{(1919-29)} \times Post$	0.1355***	0.0963***	0.0695***	0.1517***	0.1079***	0.0997***
	[0.023]	[0.022]	[0.021]	[0.052]	[0.024]	[0.026]
Observations	95,675	95,675	95,675	95,675	95,675	95,675
Adjusted R-squared	0.920	0.920	0.923	0.920	0.919	0.920

Notes: Observations are at the municipality-year level. The *Post* indicator takes value one after 1925. The variable *Dummy* takes value one as indicated in column headings. All regressions control for $\Delta lnPRI_{(1919-29)} \times Post$ as well as $Post \times Dummy$. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets.

*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

the interaction between the BG and this intervention. Column 1 shows the interaction with an indicator that takes value one if the municipality was historically affected by malaria (see the appendix for variable construction and sources). The interaction term is negative and statistically significant, confirming the findings illustrated above on the potential negative bias that would affect the estimates in the absence of this control. After land reclamation, Mussolini founded new towns to populate the newly available land. Column 2 shows the interaction with an indicator variable that takes value one if this investment in infrastructure was made within the border of the municipality. Again, the coefficient of the interaction term is not statistically different from zero.

Over the period of the regime the railroad network was expanded. This investment in infrastructure may have interacted with the BG and explain part of the positive persistent effect of the policy. For instance, areas connected with the railroad network may have benefited from technological diffusion of the new techniques and perform better in terms of economic development, ultimately entailing a positive and significant interaction term. Columns 3 examines this interaction using an indicator variable that takes value one if railroads were present in 1931. The interaction term is not statistically significant, minimizing concerns on a direct significant interaction between infrastructure and the BG. The reduction in the coefficient of interest in column 3 may be explained by the positive correlation between railroads in 1931 and exposure to the BG, which points to the endogenous response of institutions to the policy shock determined by BG.[3]

[3] More generally, the estimates of the long-term consequences of transitory policy interventions on eco-

Finally, one possibility is that the BG favored large land owners and areas characterized by high degree of land inequality. Large farms may be more likely to adopt new technologies, however inequality in the distribution of land ownership may harness human capital formation and economic development (Galor et al., 2009) entailing a (negative) bias in the estimated coefficients.[4] Thus, in columns 5 and 6, I explore the interaction of the BG with indicator variables that take values one if the Gini index of land inequality and average farm size are above the median, respectively. Both interaction terms are negative and statistically insignificant.[5]

B.5 Linkages and Manufacturing Composition

In this section, I investigate the effects of the BG on specialization in industries within the manufacturing sector. This analysis can shed light on mechanisms that are complementary with the hypothesized human capital channel. For instance, input-output linkages and Mussolini's industrial policy in strategic sectors may play important roles in explaining the persistent effect of the BG on economic development.

Employing detailed data on the labor composition from the industry census of 1971, I investigate the effect of the exposure to the policy on specialization in each industry, measured by industry-specific share of manufacturing employment. Given data limitation on industrial composition before the policy, I control for a host of municipality characteristics, province fixed-effects, and for the share of population in manufacturing before the policy. Results are illustrated in table B5.

In particular, it is possible that the agricultural technical change determined by the BG stimulated specialization in industries directly linked to grain production. I find limited evidence of this effect. In particular, column 1 shows limited evidence of the effect of exposure to the BG on the share of manufacturing labor employed in industries that use grain in production as an input. Actually, the coefficient is negative. A related finding is reported in Column 3, where the estimated coefficient is negative and significant for food related industries. This finding may be explained by the positive effect of the BG on human capital accumulation, which is conducive for the development of

nomic development should be interpreted as incorporating the endogenous response of institutions. On this point, see also Kline and Moretti (2014).

[4] Others have emphasized farm size as an important determinant of differences in agricultural productivity (Foster and Rosenzweig, 2011; Adamopoulos and Restuccia, 2014) and long-term development (Franck and Michalopoulos, 2017).

[5] Estimates of the interaction terms in columns 5 and 6 are very similar if I flexibly control for both land inequality and average farm size.

industries that are more skill-intensive than grain and food related industries. I do not find a significant effect on specialization in the production of agricultural machines, as illustrated in column 2. Neither I find an effect on industries that are related to agriculture, such as leather related production (column 4), industries related to wood products (column 5), or textile (column 6). Taken together, columns 1 to 6 show that if the BG stimulated industries linked to wheat or to the agricultural sector in general, such effect dissipated by 1971.

The industry of chemicals played a key role in the economic boom of the second half of the twentieth century. It is possible that the location of chemicals related plants was determined by the emphasis on the development of new fertilizers induced by the BG. In addition, during Mussolini's dictatorship, the government supported industries related to chemicals (Giordano and Giugliano, 2015), as well as industries related to war. Columns from 7 to 9 investigate these aspects. They show little effect of the BG on specialization in chemicals, as well as in rubber and metals related products which are typically related to war and weapons production.

Taken together, these results are coherent with the hypothesis that the BG had an effect on human capital accumulation that was conducive for industrialization in general, rather than specific industries related to agriculture or considered of strategic importance by the Fascist regime.

Table B5: Linkages and Manufacturing Composition

Dependent Variable: Share of Manufacturing Labor Force in Each Industry in 1971									
	(1) Grain	(2) Agric. Machines	(3) Food	(4) Leather	(5) Wood	(6) Textile	(7) Chemicals	(8) Rubber	(9) Metals
$\Delta lnPRI_{(1919-29)}$	-0.0075**	0.0012	-0.0265**	0.0012	-0.0090	0.0060	-0.0009	-0.0007	0.0016
	[0.004]	[0.003]	[0.011]	[0.007]	[0.006]	[0.009]	[0.004]	[0.008]	[0.010]
Observations	3,668	2,975	5,394	3,196	5,385	2,642	3,501	5,324	5,254
Adjusted R-squared	0.174	0.0438	0.242	0.0834	0.175	0.0459	0.0301	0.0874	0.128

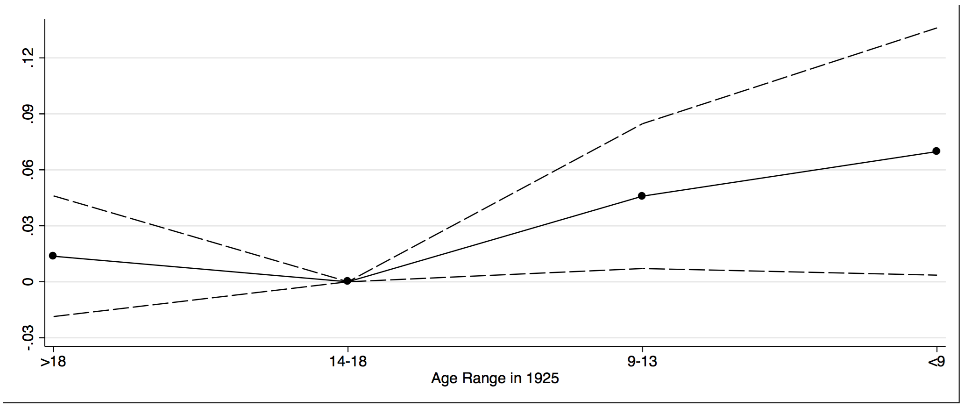
Notes: Observations are at the municipality level. All regression include province fixed-effects, land suitability for wheat, a set of geographic controls, distance to water and cities, and the share of population in manufacturing in 1911. The number of observations changes across outcome variables due to data limitation. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.6 Gender Bias and Human Capital Accumulation

B.6.1 Gender Bias and Human Capital across Cohorts

Foster and Rosenzweig (1996) have shown that, during the Indian Green Revolution, farmers invested more in the education of their male children as a response to the agricultural technical change. It is possible that a similar pattern may be present in the effect of the BG on education. I investigate this aspect restricting the analysis only to males. The estimated coefficients are depicted in figure 1. As evident from the figure, the increase in educational attainment for people of age between 9 and 13 is higher for males compared to the one for both genders (.046 compared to .032). This finding suggests that also in the case of the BG farmers invested more in the education of their sons.

Figure 1: The *Battle for Grain* and Human Capital across Cohorts: Flexible Estimates



Notes: The above figure depict the coefficient estimates of (7) for the effect of growth in the Potential Revenue Index on the average years of education across age groups for males, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects, province by cohort-group fixed effects, and flexibly controls for land suitability for wheat, land suitability for agriculture (CSI), terrain ruggedness, and historical presence of malaria. See the main text and appendices for variable definition and sources.

B.6.2 Gender Bias and Human Capital across Municipalities

In the analysis across cohorts, I have shown that the effect of the exposure to the policy is more pronounced for males. As reported in table B6, I investigate this possibility also across municipalities. The estimates are very similar to the ones illustrated in table 7. However, consistent with the cross-cohorts case, the estimated effect is slightly larger larger for males.

Table B6: The *Battle for Grain* and Human Capital of Men across Municipalities

	(1) Middle School 1951	(2) Middle School 1951	(3) Yrs of Educ. 1951	(4) Yrs of Educ. 1951	(5) Yrs of Educ. 1971	(6) Yrs of Educ. 1971	(7) Literacy 1921
$\Delta lnPRI_{(1919-29)}$	0.0916**	0.0981**	0.0930**	0.0975**	0.0972***	0.1023***	-0.0196
	[0.045]	[0.043]	[0.039]	[0.038]	[0.036]	[0.036]	[0.022]
Wheat Suit.	0.0107	0.0033	0.0062	0.0011	-0.0045	-0.0104	0.0228
	[0.024]	[0.023]	[0.024]	[0.023]	[0.021]	[0.021]	[0.017]
Literacy 1921		0.3221***		0.2225***		0.2620***	
		[0.030]		[0.028]		[0.035]	
province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to water and cities	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre Policy Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,159	6,159	6,159	6,159	6,175	6,175	6,186
Adj. R^2	0.310	0.331	0.341	0.351	0.373	0.387	0.796

Notes: This table illustrates estimates of the effect of the exposure to the *Battle for Grain* on males education across municipalities. Observations are at municipality level. Outcome variables are denoted in column headings. All variables are standardized. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.7 Additional Robustness and Placebo Checks

B.7.1 Robustness to Placebo Versions of the Potential Revenues Index with Major Crops

Table B7: Placebo Potential Revenues Index with Major Crops

	(1)	(2)	(3)	(4)	(5)
Dependent Variable: *Ln Population Density*					
$\Delta lnPRI_{wheat} \times Post$	0.0532**	0.1023***	0.0926***	0.1361***	0.0600*
	[0.021]	[0.024]	[0.034]	[0.028]	[0.032]
$\Delta lnPRI_{corn} \times Post$	-0.1831***				
	[0.023]				
$\Delta lnPRI_{rice} \times Post$		-0.0085			
		[0.040]			
$\Delta lnPRI_{olives} \times Post$			-0.0460**		
			[0.020]		
$\Delta lnPRI_{potato} \times Post$				-0.0583**	
				[0.022]	
$\Delta lnPRI_{tobacco} \times Post$					0.0328
					[0.030]
Observations	95,657	95,657	75,857	95,599	89,131
Adjusted R-squared	0.921	0.919	0.919	0.920	0.918

Notes: Observations are at the municipality-year level. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.7.2 Robustness to Alternative Versions of the Potential Revenues Index

Table B8: Alternative Versions of the Potential Revenues Index

	(1)	(2)	(3)	(4)	(5)
Dependent Variable: *Ln Population Density*					
					Placebo
$\Delta lnPRI_{(1919-29)} \times Post$	0.1003***				
	[0.022]				
$\Delta lnPRI_{(1919-29)}$ All Crops $\times Post$		0.0981***			
		[0.021]			
$\Delta lnPRI_{(1919-29)}$ Max $\times Post$			0.0931***		
			[0.024]		
$\Delta lnPRI_{(1919-29)}$ High Inputs $\times Post$				0.1354***	
				[0.016]	
$\Delta lnPRI_{(1901-11)} \times Post$					-0.0447***
					[0.016]
Observations	95,675	95,675	95,675	95,675	95,675
Adjusted R-squared	0.919	0.919	0.919	0.920	0.919

Notes: Observations are at the municipality-year level. Column 1 illustrates the baseline version my measure of exposure of the policy. Column 2 exploits an alternative version with the denominator of the PRI containing all the crops and not only the ones competing with wheat. Column 3 employs an alternative version with the maximum at the denominator of the PRI, instead of the mean. Column 4 illustrates a version based on the potential technical improvements from low to high inputs. Column 5 shows an alternative measure with prices from a placebo period. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table B9: Predictive Power of Alternative Versions of the Potential Revenues Index

	(1)	(2)	(3)	(4)	(5)
Dependent Variable: *Increase in Wheat Yield 1923-1929*					
					Placebo
$\Delta lnPRI_{(1919-29)}$	0.1382***				
	[0.042]				
$\Delta lnPRI_{(1919-29)}$ All Crops		0.1318***			
		[0.041]			
$\Delta lnPRI_{(1919-29)}$ Max			0.1457***		
			[0.045]		
$\Delta lnPRI_{(1919-29)}$ High Inputs				0.0965***	
				[0.036]	
$\Delta lnPRI_{(1901-11)}$					-0.0987***
					[0.025]
Observations	6,663	6,663	6,663	6,663	6,663
Adjusted R^2	0.448	0.447	0.447	0.446	0.448

Notes: Observations are at the municipality level. Column 1 illustrates the baseline version my measure of exposure of the policy. Column 2 shows an alternative version with the denominator of the PRI containing all the crops and not only the ones competing with wheat. Column 3 employs an alternative version with the maximum at the denominator of the PRI, instead of the mean. Column 4 illustrates a version based on the potential technical improvements from low to high inputs. Column 5 shows an alternative measure with prices from a placebo period. All regressions control for province fixed effects and land suitability for wheat. Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.

*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table B10: Alternative Definitions of Productive Crops in the Potential Revenues Index

	(1)	(2)	(3)	(4)	(5)
			Dependent Variable: *Ln Population Density*		
$\Delta lnPRI_{(1919-29)} \times Post$	0.1003***				
	[0.022]				
$\Delta lnPRI_{(1919-29)}0 \times Post$		0.0952***			
		[0.021]			
$\Delta lnPRI_{(1919-29)}10 \times Post$			0.0988***		
			[0.021]		
$\Delta lnPRI_{(1919-29)}50 \times Post$				0.0991***	
				[0.021]	
$\Delta lnPRI_{(1919-29)}100 \times Post$					0.0990***
					[0.021]
Observations	95,675	95,675	95,675	95,675	95,675
Adjusted R-squared	0.919	0.919	0.919	0.919	0.919

Notes: Observations are at the municipality-year level. Column 1 illustrates the baseline version my measure of exposure of the policy using as a definition of productive crop any crop with potential revenues per hectare higher than one lire at 1911 prices. Column 2 shows an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than zero lire. Column 3 employs an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than 10 lire. Column 4 employs an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than 50 lire. Column 5 illustrates a version using as a definition of productive crop any crop with potential revenues per hectare higher than 100 lire. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table B11: Predictive Power of the PRI with Alternative Definitions of Productive Crops

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: *Increase in Wheat Yield 1923-1929*				
$\Delta lnPRI_{(1919-29)}$	0.1382***				
	[0.042]				
$\Delta lnPRI_{(1919-29)}0$		0.1335***			
		[0.040]			
$\Delta lnPRI_{(1919-29)}10$			0.1362***		
			[0.041]		
$\Delta lnPRI_{(1919-29)}50$				0.1362***	
				[0.041]	
$\Delta lnPRI_{(1919-29)}100$					0.1366***
					[0.041]
Observations	6,663	6,663	6,663	6,663	6,663
Adj. R^2	0.448	0.447	0.448	0.448	0.448

Notes: Observations are at the municipality level. Column 1 illustrates the baseline version my measure of exposure of the policy using as a definition of productive crop any crop with potential revenues per hectare higher than one lire at 1911 prices. Column 2 shows an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than zero lire. Column 3 employs an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than 10 lire. Column 4 employs an alternative version using as a definition of productive crop any crop with potential revenues per hectare higher than 50 lire. Column 5 shows a version using as a definition of productive crop any crop with potential revenues per hectare higher than 100 lire. All regressions control for province fixed effects and land suitability for wheat. Standardized coefficients are reported. Robust standard errors clustered at the province level in brackets.

*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.7.3 Robustness to Placebo Policy Timings with Alternative Specification

Table B12: Robustness: Placebo Cutoffs and Growth

Dependent Variable: *Ln Population Density*						
	Relevant Cutoff		*Placebo Cutoffs*			
	(1)	(2)	(3)	(4)	(5)	(6)
	1861 - 2011	1911 - 1951	1881 - 1921	1871 - 1921	1871 - 1921	1861 - 1901
	Post:1925	Post:1925	Post:1911	Post:1901	Post:1881	Post:1871
$\Delta lnPRI_{(1919-29)} \times Post \times t$	0.0224***	0.0141***	0.0065	-0.0005	-0.0022	-0.0079***
	[0.004]	[0.004]	[0.007]	[0.005]	[0.003]	[0.003]
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Geography Flexible	Yes	Yes	Yes	Yes	Yes	Yes
Observations	95,646	32,364	24,763	30,919	30,919	23,687
Adjusted R-squared	0.920	0.974	0.983	0.979	0.979	0.981

Notes: This table shows estimates of the effect of the exposure to the *Battle for Grain* on the log of population density. The variable *Post* is an indicator variable that takes value one in the year indicated. Observations are at the municipality-year level. The *Post* indicator takes value one if year takes values as indicated in columns headings, the variable t is a linear time trend. Columns 3 to 6 display estimates based on placebo cutoffs. All regressions include municipality fixed effects, province-year fixed effects, in addition to land suitability for wheat, land suitability for agriculture (CSI), historical presence of malaria, and terrain ruggedness (each interacted with year indicators). Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.7.4 Robustness to Weighted Regression in the Cross-Cohorts Analysis

Table B13: The *Battle for Grain* and Human Capital Across Cohorts. Weighted Regression

	(1)	(2)	(3)	(4)
	Dependent Variable: *Average Years of Education*			
$\Delta lnPRI_{(1919-29)} \times$ Group 1	-0.0073	-0.0067	-0.0076	-0.0049
	[0.010]	[0.010]	[0.011]	[0.011]
$\Delta lnPRI_{(1919-29)} \times$ Group 2	0	0	0	0
$\Delta lnPRI_{(1919-29)} \times$ Group 3	0.0362***	0.0362***	0.0343**	0.0320**
	[0.013]	[0.013]	[0.013]	[0.013]
$\Delta lnPRI_{(1919-29)} \times$ Group 4	0.0842**	0.0832**	0.0712**	0.0650**
	[0.034]	[0.034]	[0.033]	[0.031]
Municipality FE	Yes	Yes	Yes	Yes
province $\times$ Year FE	Yes	Yes	Yes	Yes
Wheat Suitability	Yes	Yes	Yes	Yes
Geographic Controls	No	No	No	No
Observations	54,275	54,275	54,275	54,275
Adjusted R-squared	0.908	0.908	0.908	0.908

Notes: Observations are at the level of municipality-age group-gender. This table illustrates that the exposure to the *Battle for Grain* positively affected average education for schooling-aged cohorts as of 1925 (Groups 3 and 4). Group 2 is the reference group. See table 5 for the structure of the cohort groups data. All regressions control for municipality fixed effects, province by time fixed effects, gender by time fixed effects. All regressions are weighted. Weights are given by the (log of one plus) the number of individuals to which each observation is referred. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

B.7.5 Technology versus Price effect and and Human Capital Composition across Municipalites

For completeness, table B15 investigates the differential effect of the exposure to the BG on human capital composition using as an outcome the share of high school graduates by major. Column 1 shows that areas more exposed to the technological progress determined by the BG were characterized by a larger share of technical schools graduates, while areas more exposed to the price shock did not. As in table 8, the effect of the BG on the share of high school graduates in other majors is statistically insignificant.

Table B14: The *Battle for Grain*, Education, and Industrialization Across Cohorts. Weighted Regression

	Dependent Variable:			
	(1)	(2)	(3)	(4)
	Avg. Years Education	Empl. Share in Manufacturing	Empl. Share in Agriculture	Empl. Share in Others
$\Delta lnPRI_{(1919-29)} \times I_{age<14}$	0.0538**	0.0166***	-0.0124**	-0.0042
	[0.023]	[0.005]	[0.005]	[0.005]
Province-Cohorts Group FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Geography Flexible Controls	Yes	Yes	Yes	Yes
Observations	54,275	40,565	40,565	40,565
Adjusted R-squared	0.902	0.840	0.812	0.543

Notes: Observations are at the level of municipality-age group. This table illustrates that the exposure to the *Battle for Grain* positively affected average education for schooling-aged cohorts as of 1925 (column 1). The table also shows the positive effect on the transition to industry (column 2) and the negative effect on share of labor in agriculture (column 3). The sector "Others" includes services, commerce, transport, communications, finance, and public administration. The variable $I_{age<14}$ is a binary variable that takes value one if the cohort group is younger than 14 in 1925. In addition to indicated control variables and fixed-effects, regression in column 1 also includes gender by time fixed effects (gender data not available for the industry census in columns 2-4). All regressions are weighted. Weights are given by the (log of one plus) the number of individuals to which each observation is referred. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

Table B15: Technology versus Price effect and and Human Capital Composition across Municipalites

Dependent Variable: Share of High School Graduates in 1951 by Major				
			Placebo	
	(1)	(2)	(3)	(4)
VARIABLES	Technical School	Teacher Training	Classical or Scientific	Others or Unspecified
$\Delta lnPRI_{(1919-29)}Technology$	0.0643**	-0.0620	0.0021	-0.0346
	[0.032]	[0.042]	[0.046]	[0.024]
$\Delta lnPRI_{(1919-29)}Prices$	0.0368	-0.0253	-0.0114	-0.0270
	[0.024]	[0.025]	[0.035]	[0.022]
Wheat and Agricultural Suitability	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes
Distance to water and cities	Yes	Yes	Yes	Yes
Pre Policy Controls	Yes	Yes	Yes	Yes
Observations	6,393	6,393	6,393	6,393
Adj. R^2	0.371	0.195	0.156	0.0632

Notes: This table illustrates estimates of the effect of the exposure to the *Battle for Grain* on human capital composition across municipalities. Observations are at municipality level. Outcome variables are denoted in column headings and refer to the share of the population with a high school degree in each field. The residual category "Other Schools" includes other minor as well as unspecified categories All variables are standardized. Robust standard errors clustered at the province level in brackets.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

C Wheat Productivity and Comparative Economic Development across European Provinces

This section employs cross-sectional variation in geographic conditions across European provinces to document that land suitability for wheat was not conducive for economic development beyond the Italian peninsula. This result suggests that the estimated effect of the BG on economic development is not driven by differences in the geographic endowment that determines land suitability for wheat.

Figures 2 and 3 show maps of suitability for wheat and contemporary economic development across European provinces.[6] As already evident from the maps, areas more suitable for wheat tend not to be more prosperous today. In the following, I will test for the statistical relation between these two variables using variation across provinces.

Table C1 shows the results from a regression of contemporary development, measured by the natural logarithm of GDP per capita in 2011, on land suitability for wheat production, controlling for median elevation, terrain ruggedness, latitude, longitude, distance to the sea (in logs), the Caloric Suitability Index as a measure of land suitability for agriculture, and regional fixed effects.[7] Column 1 shows that, for Italy, the effect of wheat suitability is positive and statistically significant. In contrast, column 2 shows estimates of the same regression across European provinces excluding Italy. The coefficient of interest is negative and statistically significant. Columns 3 to 6 depict similar estimates for selected European countries. For France and Germany, estimates are negative and significant.[8] For what concerns the United Kingdom and Spain, the estimates are statistically insignificant.

The evidence reported in this section supports the hypothesis that geographic conditions that make areas more suitable to produce wheat are not conducive for economic development. Given that wheat suitable places were more exposed to the BG, this finding minimizes concerns on the potentially confounding effect of geography in the estimates of the effect of the policy.

[6] Economic development is measured by income per capita in 2011. See appendix E for variable sources.
[7] Regional fixed effects are at the NUTS 2 level.
[8] Throughout the period of the BG, Italy and France were the biggest consumers of wheat (Cohen, 1979)

Figure 2: Land Suitability for Wheat acrosss European Provinces

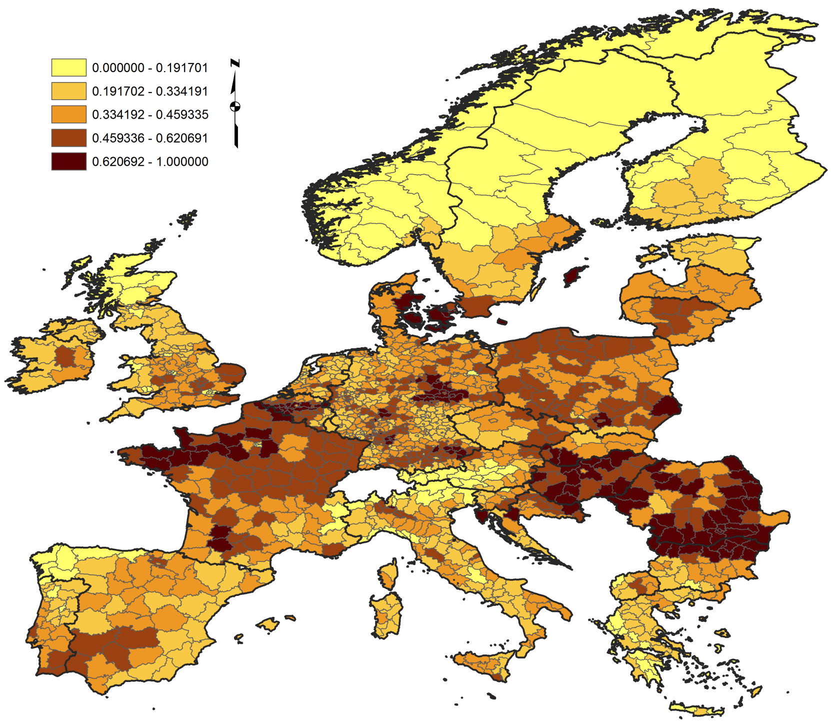


Figure 3: GDP per capita in 2011 (logs).

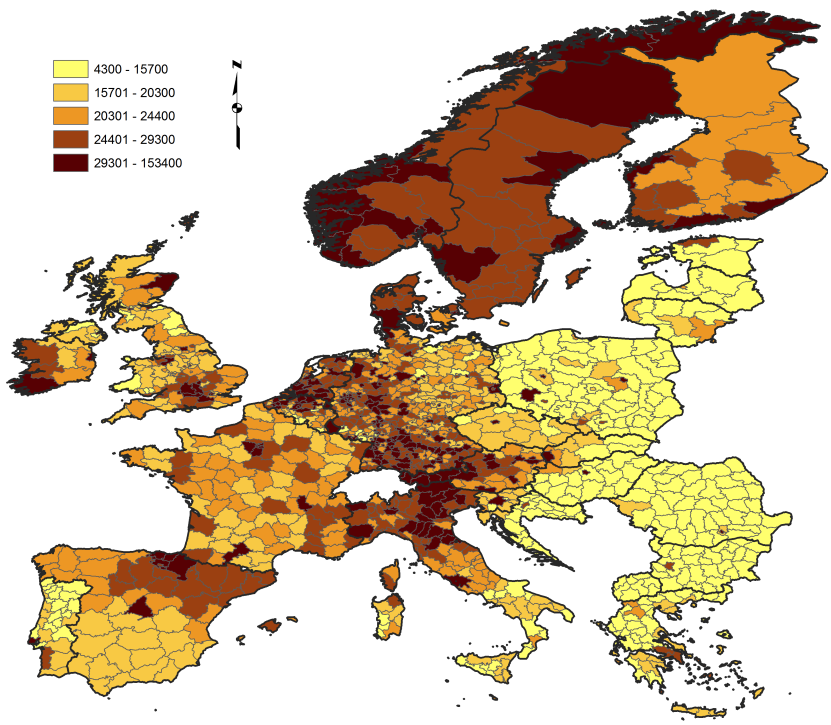


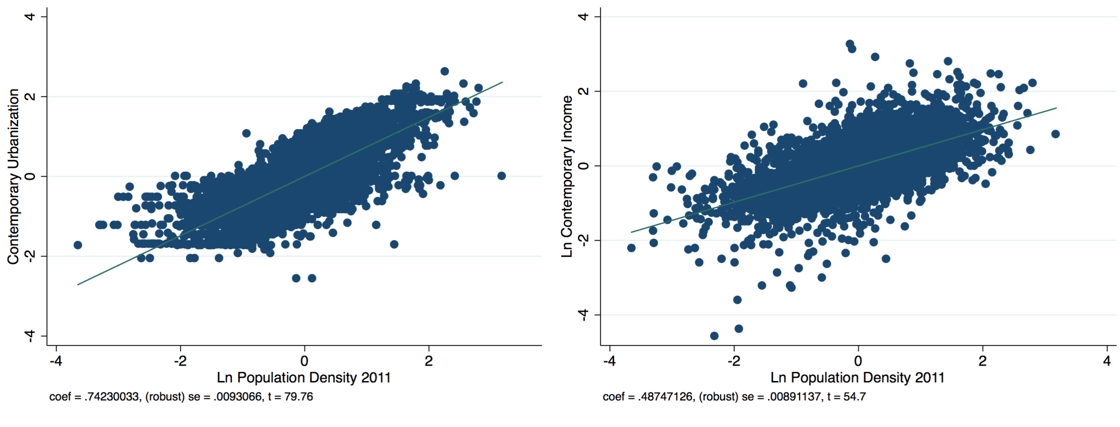
Table C1: Land Suitability for Wheat and Development in Europe. OLS

	Dependent Variable: *Ln Contemporary Income*					
	(1)	(2)	(3)	(4)	(5)	(6)
	Italy	Europe (No Italy)	France	Germany	UK	Spain
Wheat Suitability	0.2928**	-0.4945***	-0.9187**	-0.6288***	-0.0754	0.0512
	[0.122]	[0.104]	[0.412]	[0.156]	[0.303]	[0.213]
Std. β	0.124	-0.178	-0.633	-0.228	-0.0334	0.0269
Observations	110	1,211	97	403	138	55
R^2	0.167	0.200	0.326	0.188	0.123	0.155

Notes: This table establishes that the reduced form effect of land suitability for wheat on comparative economic development is positive across Italian Provinces, while it is negative across European Provinces outside of Italy. Provinces are defined by NUTS 3 borders as of 2010. All regressions control for: latitude and longitude, median elevation, standard deviation of elevation, land productivity for agricultural production (Caloric Suitability Index), distance to the sea (in logs), and regional (NUTS 2) fixed effects. The coefficient for Spain turns negative and statistically insignificant if one outlier is removed. Robust standard errors in brackets clustered at regional (NUTS 2) level.
*** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

D Figures

Figure 4: Population Density and Economic Development

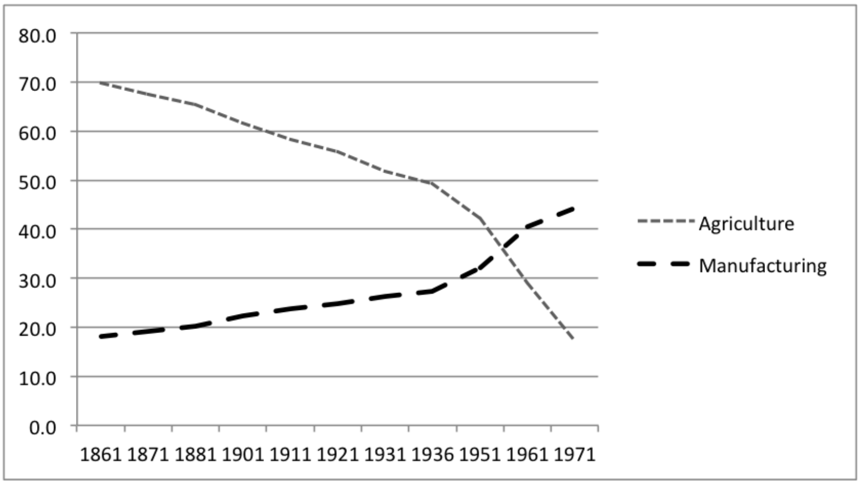


(a) Urbanization

(b) Income

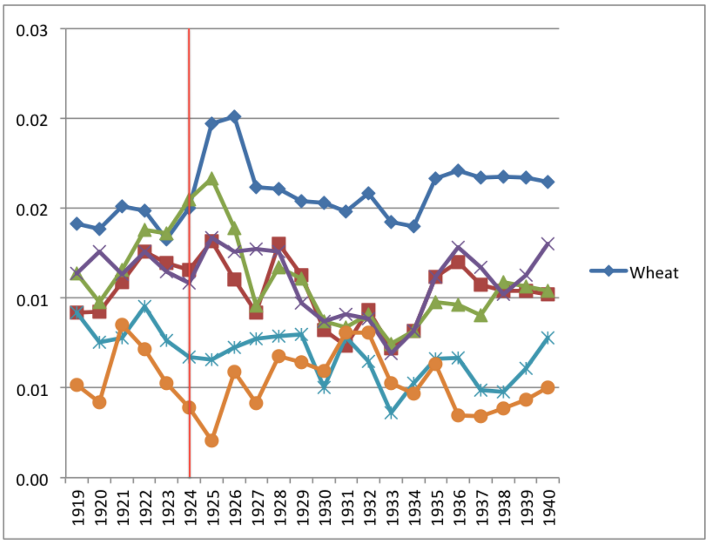
Notes: These figures report estimates that underline the validity of population density as a measure of economic development across Italian municipalities in contemporary periods. Panel 4a depicts the association between a measure of contemporary urbanization in logs (ISTAT) and the log of population density in 2011 after controlling for contemporary provinces fixed effects. Panel 4b depicts the association between average per capita income over the years 2008-2012 (ISTAT) and population density in 2011 after controlling for province fixed effects. All variables are standardized.

Figure 5: Employment Shares in Agriculture and Manufacturing



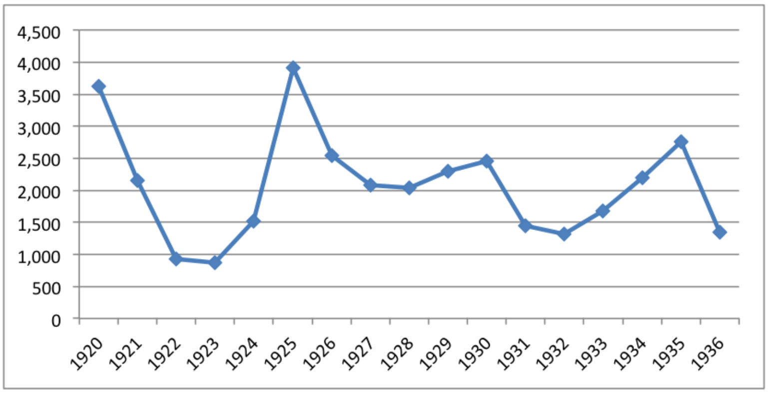
Notes: This figure depicts the employment share in agriculture and manufacturing over time (Source: ISTAT). Note that, at the time when the *Battle for Grain* was introduced (1925) the share of employment in agriculture was above 50%.

Figure 6: Real Price of Wheat and Selected Crops



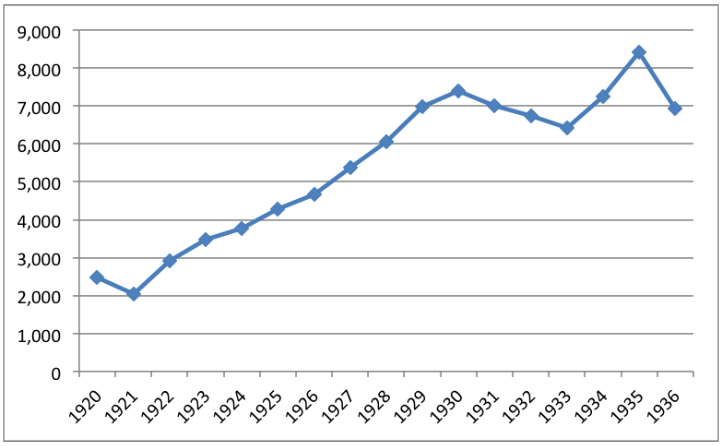
Notes: Price of wheat and other crops normalized by the Consumer Price Index in Malanima (2002).

Figure 7: Imports of Steel and Iron Products



Notes: This figure shows that imports (in thousand of quintals) of steel and iron products does not exhibits the downward pattern displayed by wheat imports over the period of the *Battle for Grain*. Source: ISTAT.

Figure 8: Imports of Oil and Derivatives



Notes: This figure shows that imports (in thousand of quintals) of raw mineral oils and derivatives does not exhibits the downward pattern displayed by wheat imports over the period of the *Battle for Grain*. Source: ISTAT.

Figure 9: Domestic price of soft and hard wheat. Source: ISTAT.

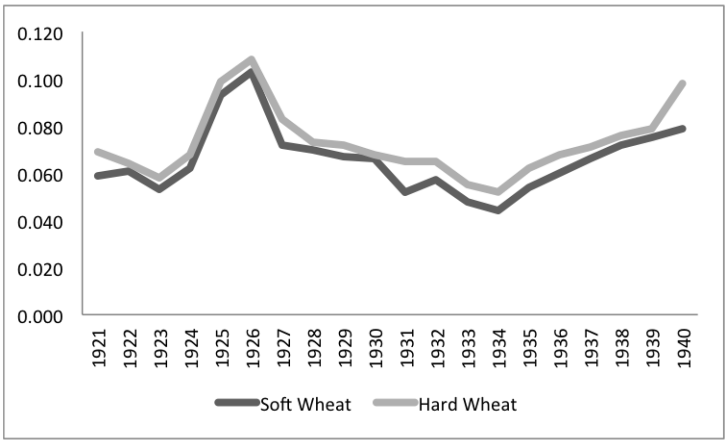
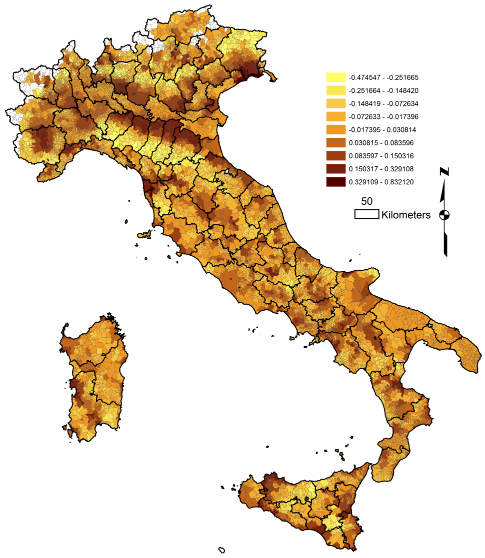
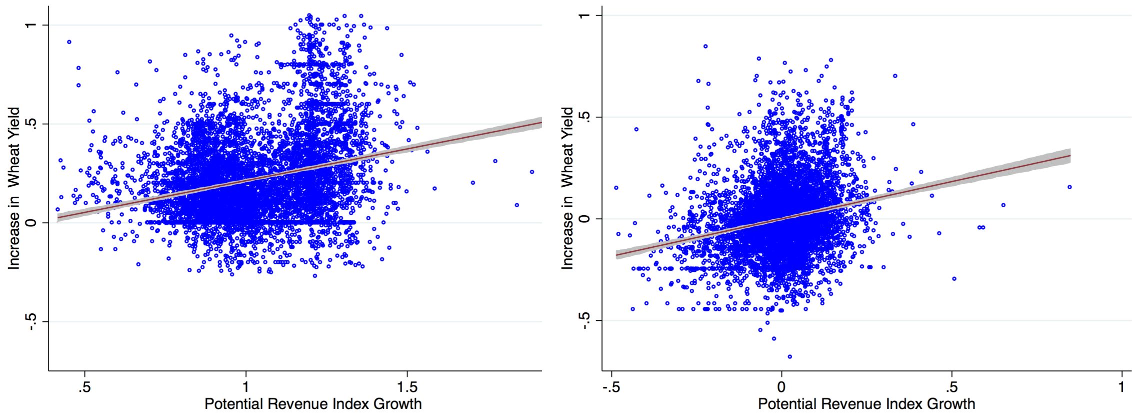


Figure 10: The Potential Returns from the *Battle for Grain*



Notes: The map shows $\Delta lnPRI_{(1919-29)}$ after controlling for province-fixed effects.

Figure 11: The Exposure to the *Battle for Grain* and the Wheat Yield Increase

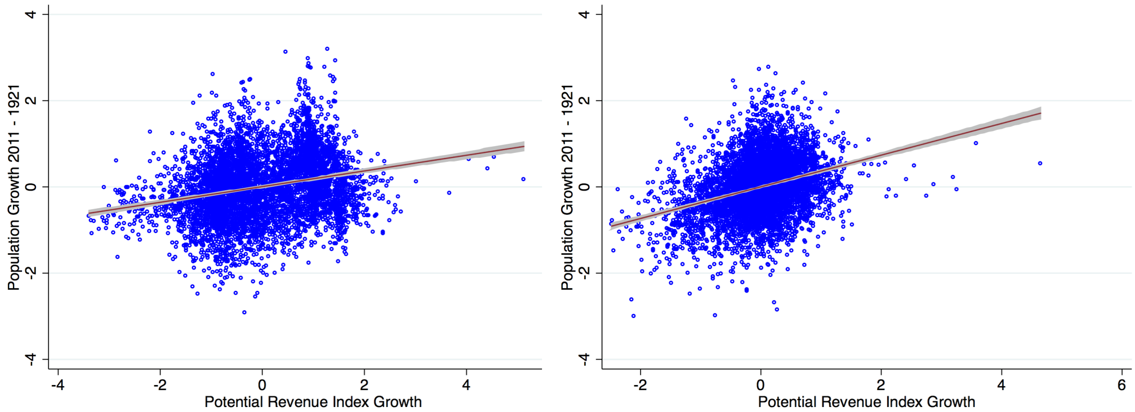


(a) Unconditional

(b) Province Fixed Effects

Notes: Panel (a) shows the scatter plot of the unconditional relationship between the increase in wheat yield over the years from 1923 to 1929 and my measure of the potential returns from the Battle for Grain, and 95% confidence intervals. Panel (b) takes into account province-fixed effects.

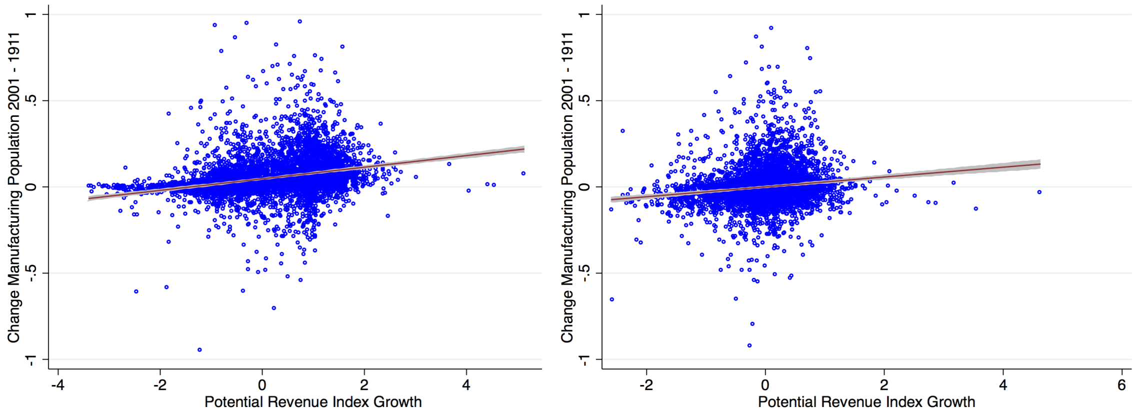
Figure 12: The Exposure to the *Battle for Grain* and Population Growth



(a) Unconditional (b) Province Fixed Effects

Notes: Panel (a) shows the scatter plot of the unconditional relationship between the increase the growth in population between 1921 and 2011 and my measure of the potential returns from the Battle for Grain, and 95% confidence intervals. Panel (b) takes into account province-fixed effects.

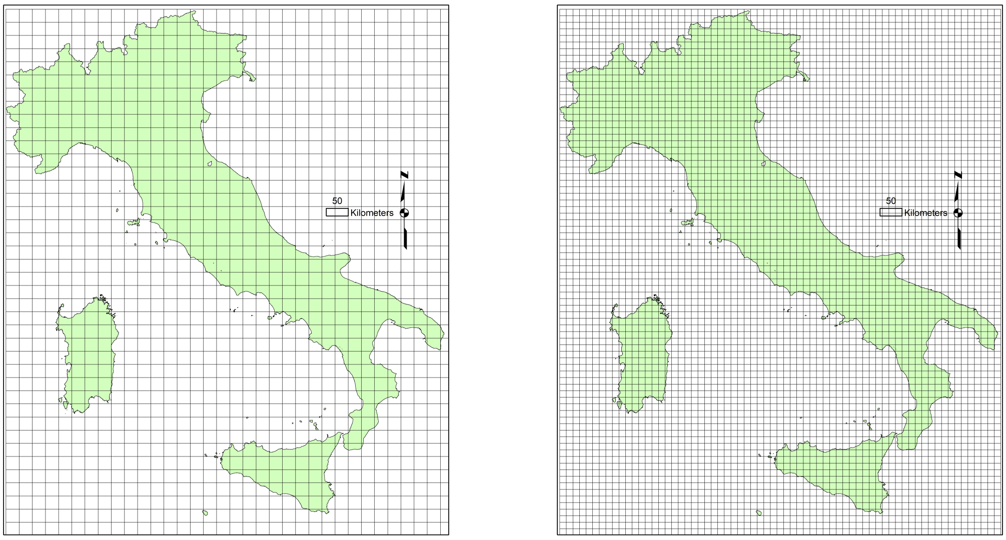
Figure 13: The Exposure to the *Battle for Grain* and Industrialization



(a) Unconditional (b) Province Fixed Effects

Notes: Panel (a) shows the scatter plot of the unconditional relationship between the change in the chare of the population in manufacturing and my measure of the potential returns from the Battle for Grain, and 95% confidence intervals. Panel (b) takes into account province-fixed effects.

Figure 14: Grid Size Examples: Spatial Analysis



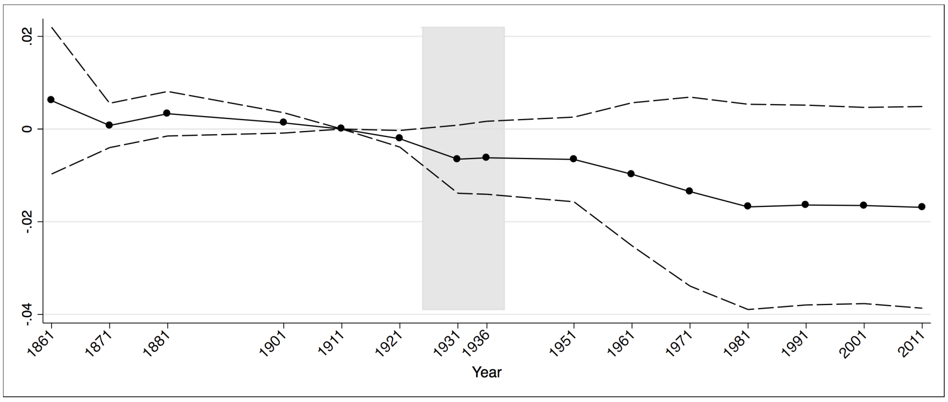
(a) 30 km^2 Grid (b) 15 km^2 Grid

Notes: The panels show the size of the grid used in the spatial analysis for 30 and 15 km^2 respectively.

Figure 15: Railroads in Italy 1931-1934

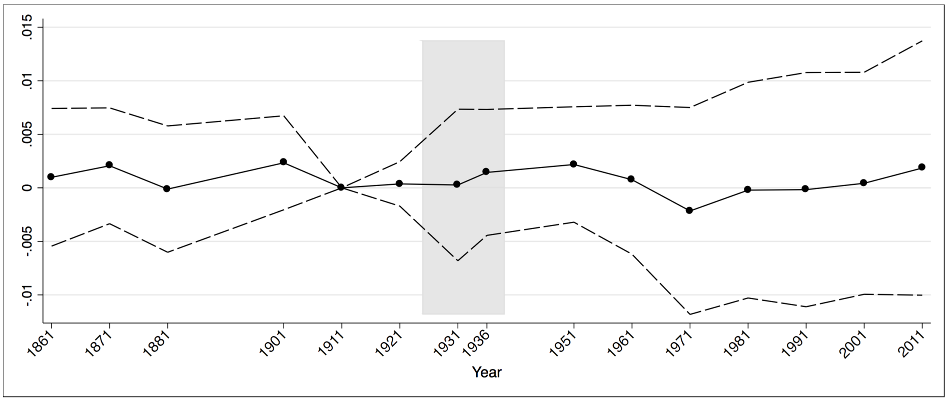
Notes: This figure depicts the map of railroads in 1931. No expansion of the railroad network was undertaken until 1934.

Figure 16: Placebo Estimates: Change in Potato Yield and Population Density



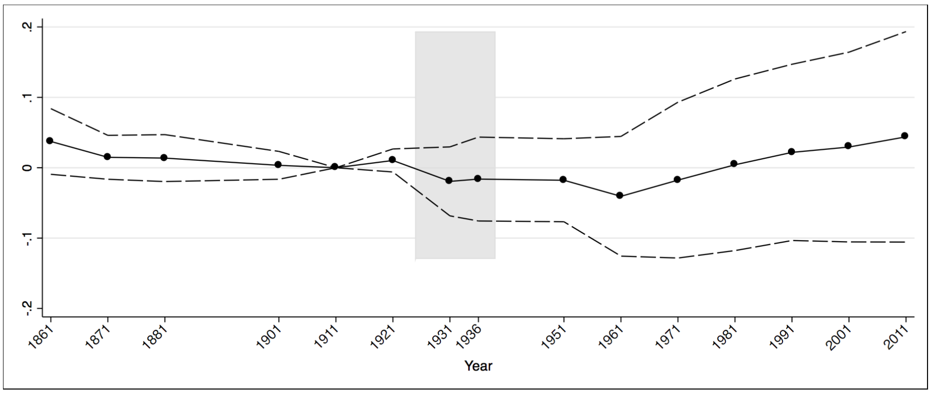
Notes: The above figure depicts the coefficient estimates of (1) from regressing population density measured in natural logarithms on the change in potato yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

Figure 17: Placebo Estimates: Change in Rice Yield and Population Density



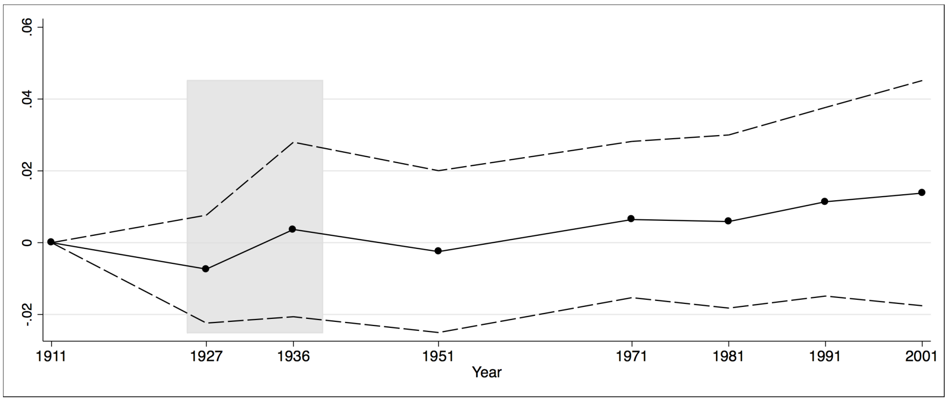
Notes: The above figure depicts the coefficient estimates of (1) from regressing population density measured in natural logarithms on the change in rice yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

Figure 18: Placebo Estimates: Change in Corn Yield and Population Density



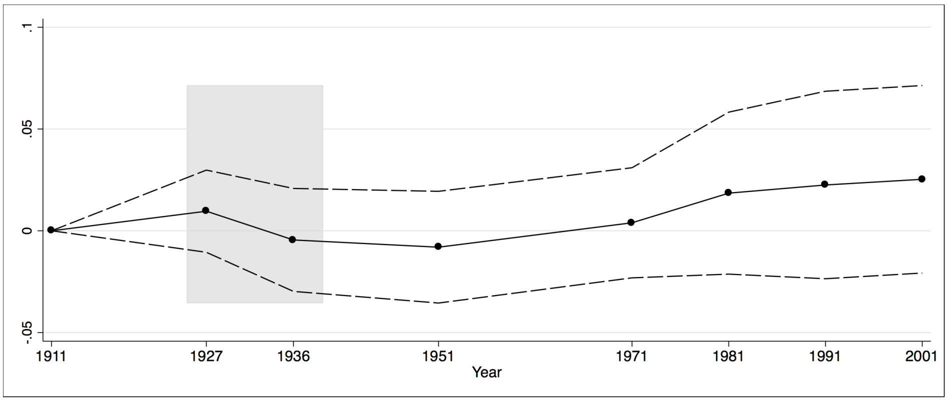
Notes: The above figure depicts the coefficient estimates of (1) from regressing population density measured in natural logarithms on the change in corn yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

Figure 19: Placebo Estimates: Change in Potato Yield and Industrialization



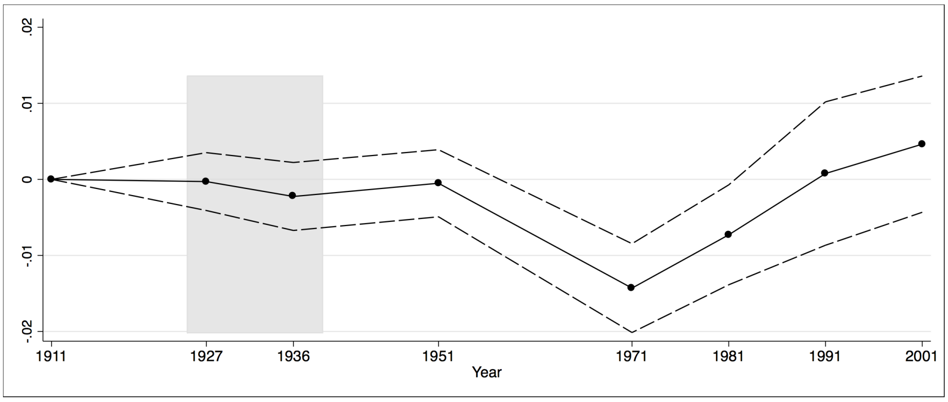
Notes: The above figure depicts the coefficient estimates of (1) from regressing the share of population in manufacturing on the change in potato yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

Figure 20: Placebo Estimates: Change in Rice Yield and Industrialization



Notes: The above figure depicts the coefficient estimates of (1) from regressing the share of population in manufacturing on the change in potato yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

Figure 21: Placebo Estimates: Change in Corn Yield and Industrialization



Notes: The above figure depicts the coefficient estimates of (1) from regressing the share of population in manufacturing on the change in corn yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from a regression that include municipality fixed effects and province specific time fixed effects. See the main text and appendices for variable definition and sources.

E Variables description and sources

Table E1: Summary statistics for Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Increase in Wheat Yield 1923-1929	0.222	0.22	-0.269	1.049	6893
$\Delta lnPRI_{(1919-29)}$	1.036	0.182	0.417	1.969	6870
Latitude	43.386	2.552	36.706	46.988	6901
Malaria 1870	0.3	0.458	0	1	7026
Cal. Suitab. Index	4191.296	790.072	0	5636.359	6970
Median Elevation	420.554	438.667	1	2728	6892
Ln (Max - Min Elevation)	5.591	1.727	0	8.220	6897
Std. Dev. Elevation	134.468	145.101	0	870.356	6969
Dist Waterways	7.034	8.926	0	87.812	6970
Distance to Major Urban Centers, Km	122.742	92.982	0	442.65	6900
Km Roman Roads per Sq. Km	0.216	0.901	0	47.587	6899
Ln Pop. Density 1921	18.588	0.852	14.615	22.592	6537
Ln Mkt. Access 1921	11.934	0.261	10.993	12.622	6535
Share Middle School 1951	0.057	0.038	0	0.334	6860
Avg. Years Education 1951	5.394	0.233	5	7.437	6860
Avg. Years Education 1971	6.188	0.413	5.125	8.436	6882
Literacy Rate 1921	0.724	0.211	0.006	1	6485
Grain Industry Empl. 1971	0.045	0.068	0	0.5	4225
Agric. Machines Empl. 1971	0.023	0.059	0	1	3390

Suitability for agriculture. The variable is based on the Caloric Suitability Index (Galor and Özak (2016), Galor and Özak (2015)). The index measures the average potential agricultural output (measured in calories) across productive crops in each cell 5'×5' for the World. The measure is the average Caloric Suitability across the grid cells within a municipality.

Suitability for wheat production. Wheat potential yield per hectare from the FAO GAEZ' v3 methodology with low inputs and rain-fed conditions.

Malaria in 1870. The variable takes value one if the centroid of the municipality is less than 5 kilometers away from malarial zones. Malarial zones are calculated from the map of malaria prevalence in Italy in 1870 from Torelli (1882).

Elevation variables. Median and standard deviation of elevation are calculated with GIS software using the GOTOPO 30 - 30 arc seconds resolution elevation data from U.S.Geological Survey. The measures are calculated across grid cells within a municipality. Elevation range is calculated taking the natural logarithm of the difference between maximum and minimum elevation in each municipality. Data on minimum and maximum elevation are from ISTAT and are more precise than those from the GOTOPO 30 data set.

Market Access 1921. Average population as of 1921 in all other municipalities weighted by distance (Harris, 1954).

Distance to waterways. Minimum distance from major rivers and coastline in kilometers.

Distance to major cities. Distance in kilometers to the most populous cities in 1921: Milan, Naples, Palermo, Rome, and Turin.

Population density. The natural logarithm of population over municipality area. Population data are from the Population Censuses. They were taken in the years 1861, 1871, 1851, 1901, 1911, 1921, 1931, 1936, 1951, 1961, 1971, 1981, 1971, 1981, 1991, 2001, and 2011. No Population Census was conducted in 1891 or 1941. To calculate population density I divide total population (age 6 or older) over municipality area, where the latter is calculated following the procedure explained in the appendix section on changes in administrative borders. Note that in the main specification municipality-level fixed-effects are taken into account. Therefore using the log of population is numerically equivalent to the log of population density as municipality area is constant over time. Population census data are from publications of the Italian Statistical Office (ISTAT).

Manufacturing Population share. Number of people employed in manufacturing over the total population (6 years or older). I opted for this measure as data for the labor force are not available for all the years. Data for the number of people employed in manufacturing in 1911, 1927, 1981, 1991, and 2011 are from the industry censuses. I have digitized the industry censuses for 1911 and 1927. For the years 1936, 1951, 1971 manufacturing employment data are from the population censuses. I have digitized population censuses in 1936 and 1951. Population data for 1927 are not available, thus I use population in 1931 at the denominator of the share of manufacturing population in 1927 because is the closest year for which the Population Census is available. Industry census data are from publications of the Italian Statistical Office (ISTAT).

Share of middle school graduates in 1971. Number of people with at least a middle school degree relative to the population aged over 14, measured in 1971. Source: Population Census 1971.

Average years of education. The variable is calculated assigning to each degree the number of years necessary to attain the degree in a procedure similar to Barro and Lee (1993). Specifically, I consider 5 years for elementary school, 3 years for intermediate school, 5 years for high school, and 5 years for university degree. Results are unchanged using 4 years for high school or for university degree. For the average years of education across municipalities, I cannot consider individuals without a degree because I do not have information on their age and thus I cannot assess whether they are part of the adult population. In this case the variable measures the average number of years of education conditioning of having a degree. Thus, in line with the advanced hypothesis, the variable measures education on the intensive margin, rather than the extensive one.

Industry-specific manufacturing employment. Number of people employed in each manufacturing industry over the total number of people employed in manufacturing in 1971. Source: Census of Industry 1971.

Railroads 1931-34 Indicator variable taking value one if the railroads go through the municipality border in 1931. Between 1931 and 1934 no expansion of the railroad network was undertaken. I have digitized the railroads map from the historical map of railroads by Pozzo Turin (figure 15).

E.1 Cross-Cohorts Data Sources

Data across age groups are from the census of population at the individual level from ISTAT. I have elaborated the education data at the ISTAT laboratory (ADELE) and aggregated following the privacy rules of the laboratory. For the average years of education across cohorts, I assign zero years of education to people without a degree. Different specifications of the variable could not be released as they would violate privacy laws.

E.2 Europe Data Sources

Gross domestic product (GDP). Measured in Purchasing Power Standard per inhabitant by NUTS 3.

NUTS. Nomenclature of Territorial Units for Statistics 2010, borders are from European Commission, Eurostat (ESTAT), GISCO.

Geographic data for Europe are from the same sources as for the Italian data set and elaborated using GIS software.

E.3 Administrative Changes in Municipality Borders and Names

The municipality-level data used in this paper cover the period 1861-2012. Overall, municipality borders were fairly stable over time. However, administrative changes at the level of municipalities took place. In particular, most of the municipalities that were subject to changes in borders were divided into multiple units. At the time when this paper is written, digitized data for historical borders of Italian Municipalities are not available.

Therefore, in order to have consistent unit of observation, I map historical municipalities with municipalities as of 2012 based on municipality names for each historical period for which I have data. Information about changes in municipality names were taken into account so that historical municipality were consistently merged with contemporary municipalities even if their name changed. Information on changes of municipality names and administrative changes are from ISTAT (Italian Statistical Office), SISTAT (*Sistema Informativo Storico delle Amministrazioni Territoriali*), *Agenzia delle Entrate* (the Italian Revenue Agency), and sometimes complemented with data from the official websites of the municipalities.

The set of historical municipalities that divided into two or more units are characterized by multiple contemporary observations for each historical data point. After mapping historical municipalities with contemporary ones using the above sources, I aggregate the contemporary observations to their historical borders based on the area of each municipality according to contemporary borders.

A very small set of municipalities merged over the period of study (around 1% per census). In these cases, multiple historical observations are associated with a unique contemporary data point. Given the lack of information on historical borders, I aggregate these historical data points to their contemporary borders, so that they are characterized by a unique data point that is consistent over time.

Results are robust to the exclusion of municipalities that experienced any changes in administrative borders over the period considered.

E.4 FAO Potential Productivity Data

The FAO's Global Agro-Ecological Zones project (GAEZ) v3.0 constructed crop specific measures of potential production capacity in terms of output density by grid cell. Such measures of potential productivity are constructed combining geo-referenced global climatic data (precipitation, temperature, wind speed, sunshine hours and relative humidity, etc.), soil and terrain data.

The crops I consider are those for which price data are available: Citrus, Maize, Oats, Olive Oil, Phaseolus Beans, Potatoes, Tobacco, Tomatoes, Wheat, Wet Rice.[9]

Crop-specific potential yield data are measured in dry weight per hectare. Since the variable I construct as a predictor of the potential effects of the policy uses price data for produces in harvest weight, dry weight was converted to harvested weight using the conversion factors provided by the GAEZ model documentation. Price data for beans are referred to the dry produce, so no conversion was needed. For olives, the GAEZ data refers to Olive Oil, thus price for olive oil is considered and thus no conversion was needed. Price of tobacco is considered for the dry produce, so no conversion was needed.

The FAO GAEZ documentation does not provide a conversion factor from dry to harvested weight for citrus. Therefore I use the USDA water content to calculate a conversion factor over 5 crops that can be considered similar so citrus (carrot, tomato, cabbage, banana, onion). The USDA conversion factor for these crops is on average 0.614457143 times the conversion factor from GAEZ for the above crops. Therefore I impute to citrus a conversion factor that is 0.614457143 times the conversion factor calculated from the USDA National Nutrient Database for Standard Reference Release 28 (which is 7.547169811).

[9] According to the FAO GAEZ estimates, Italy is not suitable for Dry Rice production with rain-fed conditions, thus only Wet Rice is considered.

F Nonclassical Measurement Error in the Agricultural Data

F.1 Increase in Wheat Yield as Independent Variable

This section establishes that the estimates of the OLS specification in the empirical analysis in section 5 are biased downward under natural assumptions. The proof is an application of the *mean reverting measurement error* by Bound and Krueger (1991).

Assume for simplicity that the structural model is given by

$$Y_i = \beta \Delta q^* + \varepsilon_i \tag{1}$$

where Y_i represents an outcome variable for municipality *i*. $\Delta q^* \equiv (q_{29} - q_{25})$ represents the change in tons of wheat per hectare between the year 1925 and 1929 (the policy was implemented after the harvest of 1925.), which is unobserved.[10]

What is instead observed is $\Delta q \equiv (q_{29} - \bar{q}_{23-28})$, where $\bar{q}_{23-28}$ is an average of the productivity over the period 1923-1928, which thus includes three years before and and three years after the policy. Given what is observed, the estimated model is

$$Y_i = \hat{\beta} \Delta q + \eta_i \tag{2}$$

where it is assumed that

$$E[\eta_{it} \ \varepsilon_{it}] = 0 \tag{3}$$

Note that Δq can be written as the difference of the unobserved policy driven productivity change and a measurement error term. Namely,

$$\begin{aligned} \Delta q &\equiv (q_{29} - \bar{q}_{23-28}) &(4)\\ &= (q_{29} - q_{25}) - (\bar{q}_{23-28} - q_{25}) &(5)\\ &\equiv \Delta q^* - \Delta q^0 &(6) \end{aligned}$$

where Δq^* is what I would like to observe and Δq^0 is a measurement error. To simplify the notation

[10] To lighten the notation, in this section I will exclude the superscript *w*.

$$
\begin{aligned}
Var[\Delta q^*] &\equiv \sigma && (7)\\
Var[\Delta q^0] &\equiv \sigma_0 && (8)\\
Cov[\Delta q^*, \Delta q^0] &\equiv \lambda && (9)
\end{aligned}
$$

To assess the size of the bias, note that the OLS estimate of β is given by

$$\hat{\beta} = \frac{Cov[\Delta q^* - \Delta q_0, \beta \Delta q + \varepsilon_{it}]}{Var[\Delta q^* - \Delta q^0]} \tag{10}$$

therefore

$$
\begin{aligned}
plim\hat{\beta} &= \beta\Big[\frac{\sigma - \lambda}{\sigma + \sigma_0 - 2\lambda}\Big] && (11)\\
&= \beta\Big[1 - \frac{\sigma_0 - \lambda}{\sigma + \sigma_0 - 2\lambda}\Big] && (12)
\end{aligned}
$$

Therefore if λ is non positive, the sign of the bias is negative. If λ is positive, the sign of the bias is negative under the weak restriction that $\sigma_0 > \lambda$. This assumption, common in the econometric literature (Black et al., 2000), simply says that the covariance between the true unobserved independent variable, Δq^*, and its measurement error, Δq_0, cannot be so strong that it more than overcome the variance of the measurement error itself.

F.2 Error in predicting the Increase in Wheat Yield

In the following, I investigate the effect of non classical measurement error in Δq on the coefficient of a regression in which the variable measured with error is the dependent variable and the independent variable is given by the potential returns from the BG. The coefficient is reported in the second column of table 1. Although this is a standard approach in econometric textbooks, it is useful to briefly illustrate the structure of the problem so that I can develop a simple extension and study of how the magnitude of the estimated coefficient are affected.

Consider, for simplicity, a uni-variate model of the form

$$\Delta q^* = \phi \Delta lnPRI + \eta_i$$

Given (6), I can write

$$\Delta q^{w} = \phi \Delta lnPRI + \eta_i - \Delta q_0 \tag{13}$$

The OLS estimate of ϕ is given by

$$\hat{\phi} = \frac{Cov[\Delta q, \Delta lnPRI]}{Var[\Delta lnPRI]} = \frac{Cov[\phi \Delta lnPRI + \eta_i - \Delta q_0, \Delta lnPRI]}{Var[\Delta lnPRI]} \tag{14}$$

therefore

$$plim\hat{\phi} = \phi - \frac{Cov[\Delta lnPRI, \Delta \tilde{q}_0^{w}]}{Var[\Delta lnPRI]} \tag{15}$$

This result shows that, if $Cov[\Delta lnPRI, \Delta \tilde{q}_0^{w}] > 0$, the estimated coefficient will be biased downward.

Next, I add two assumptions on the structure of the error term $\Delta \tilde{q}_0$. First, I assume that wheat yield was constant before the BG. Namely, $q_{1925} = q_{1924} = q_{1923}$. Second, I assume constant increments in wheat yield over the years after the introduction of the policy. Namely, $q_{1926} - q_{1925} = q_{1927} - q_{1926} = q_{1928} - q_{1927} = q_{1929} - q_{1928}$. These assumptions, will be useful to get a sense of the quantitative effect of the measurement error on the estimated coefficient.

Given the assumptions, I can write

$$\Delta \tilde{q}_0^{w} = \frac{1}{4} \Delta q_0^{w}$$

which, substituted in (15), implies that

$$plim\hat{\phi} = \frac{3}{4}\phi \tag{16}$$

Suggesting that the estimated parameter for the first stage should multiplied by 4/3 to consistently estimate the parameter of interest. Therefore, the estimated coefficient in table table 1 in columns two 0.1381 should be approximately 0.1831.

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