Agricultural Productivity and Long-Run Development: Evidence from Mussolini's *Battle for Grain*[*]

Mario F. Carillo[†]

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Abstract

This paper studies the effect of an increase in agricultural productivity on industrialization and economic development in the long run. I explore the effects of the *Battle for Grain*, a policy implemented by the Italian Fascist regime in 1925 to achieve self-sufficiency in wheat production through technological improvements and tariffs on wheat import, on the development path across areas of Italy. To conduct the analysis, I build a novel dataset on the evolution of economic performance across 7000 Italian municipalities over the last 100 years. Exploiting time variation arising from the implementation of the policy, along with exogenous cross-sectional variation in the potential increase in wheat productivity, I find that the policy-induced rise in agricultural productivity had unintended positive effects on industrial development which persisted until today. I investigate the mechanisms distinguishing empirically between the price component and the technological component of the policy. I find that the positive effect of the policy on long-run development is governed predominantly by the effect of technological advancements on human capital accumulation and industrialization, rather than by the price effect. The results suggest that the complementarity between human capital and agricultural technology is an important channel through which a rise in agricultural productivity can foster structural transformation. (JEL: *F13, N54, O13, O14, O33, Q16, Q17, J24*)

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[†]Brown University, Department of Economics, Robinson Hall, 64 Waterman st. Providence, RI 02912. Mario_Francesco_Carillo@Brown.edu

1 Introduction

The effect of agricultural productivity on the process of industrialization and long-run economic prosperity is a longstanding debate in the development literature. While a rise in agricultural productivity may foster urbanization and industrial development if the demand for agricultural goods is limited, higher agricultural productivity may strengthen comparative advantage in agriculture and delay the process of industrialization and long-run prosperity.[1]

This paper studies the effect of an increase in agricultural productivity on industrialization and long-run prosperity. I analyze the differential effect of the *Battle for Grain*, implemented by the Italian Fascist regime to achieve self-sufficiency in wheat production through technological improvements and tariffs on wheat import, on the development path across areas of Italy. I exploit time variation, along with exogenous cross-sectional variation in the potential increase in wheat productivity, to show its unintended positive effects on industrialization and long-run economic development. I investigate the mechanisms distinguishing empirically between the price component and the technological component of the policy. I find that the positive effect of the policy on long-run development is governed predominantly by the positive effect of technological advancements on human capital accumulation and industrialization, rather than by the price effect. The differential effect of the *Battle for Grain* across areas with different geographic characteristics, as well as its temporary nature, make this historical event a unique experiment in the empirical investigation of the effect of an increase agricultural productivity on economic development in the long run.[2]

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 the pro-

[1] See section 2 for an overview of the related literature.

[2] For other works that study the long-run consequences of historical events, see for instance Dell (2010); Acemoglu et al. (2011); Valencia Caicedo (2014); Michalopoulos and Papaioannou (2016); Franck and Michalopoulos (2017).

duction of wheat.[3] The intervention triggered a significant technical change in wheat production via a stimulus to new wheat production techniques[4] — including improved wheat seeds, machines, and fertilizers— which was similar to the Green Revolution.[5] In order to give farmers incentives to intensify wheat production and adopt the new production techniques, significant tariffs in wheat were implemented. Thus, the policy had two characteristics, technical change and protection. The heterogeneous effect of these interventions allows me to study these two aspects separately.

To perform the empirical analysis, I digitized historical records at the level of Italian municipalities from several sources such as the 1929 Census of Agriculture, Censuses of Population, Censuses of Industry, and several historical maps. Furthermore, I combine these data with highly disaggregated data on education and sector-specific employment across age groups within municipalities. The data set covers about 7000 municipalities by decade over the course of the 20th century and beyond.

In a first step of the empirical analysis, I document that areas where wheat yield increased over the years of the BG experienced an expansion of economic activity, measured by population density, and industrialization that emerged after implementation and persisted long after its repeal and until today.[6] Yet, reverse causality may affect the estimates. For example, an increase in population, and the associated higher demand for food, could

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

[4] On the positive link between agricultural technical change and agricultural productivity, see Kantor and Whalley (2014).

[5] 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 eventually have been adopted in several other countries such as China, Argentina, and Mexico. Recently, Strampelli has been named "the prophet of the Green Revolution" (Salvi et al., 2013).

[6] Population is a common measure of economic activity for historical periods (Dittmar, 2011; Nunn and Qian, 2011; Squicciarini and Voigtländer, 2015), as well as for contemporary periods (Glaeser et al., 1995; Gonzalez-Navarro and Turner, 2016). Across Italian municipalities, a one standard deviation (SD) increase in contemporary population density is associated with 80% of a SD higher degree of urbanization, and with 50% of a SD higher contemporary income per capita (See figure 17).

raise the returns from increasing 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 to build a measure of the potential exposure to the policy. Then, I employ this measure interacted with time indicators in a flexible specification. The identification strategy requires that there were no other factors correlated with 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-Ecological Zones (GAEZ) methodology 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 crop 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 protection. 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, measured by the share of population working in manufacturing. The estimated effects are sizable. In particular, a one standard deviation increase in the potential returns from the policy implies 22% larger contemporary population density and 12% of a standard deviation larger share of people in manufacturing in recent years, relative to a pre-policy period.

Given that the measure of the profitability of the BG is based on the potential returns rather than the actual ones, 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,[7] thus accounting for time-invariant factors as well as time-varying characteristics across provinces (and regions) that caused differential patterns between north and south of the country.[8] 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.[9] In addition, I control for ruggedness, which is a determinant of technology adoption across all crops and not only wheat. 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 industrialization and economic development, I turn to an analysis of potential mechanisms through which it operated. Several works emphasized the importance of the complementarity between technological progress in agriculture and human capital accumulation (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 determined by the BG raised the returns from investing in human capital, stimulated investment in education, ultimately triggering industrialization and long-term

[7] Provinces are referred to NUTS 3 level as they were in 1929. The number of province fixed effects included is 91. Controlling for 110 provinces as of 2010 rather than historical ones does not affect the results.

[8] See for instance, Daniele and Malanima (2011), Zamagni (1993), Felice (2013).

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

economic development.[10]

To investigate this hypothesis, I follow two approaches. First, I employ cohort-specific variation in educational attainment within municipalities in 1971. The idea is that the higher incentives to accumulate education determined by technical change should have been more pronounced for people who were in their school age when the policy was implemented. My findings support this hypothesis. In particular, I illustrate that, within municipalities more exposed to the policy, people who were school-aged children when the policy was implemented were significantly more educated than older cohorts.[11] Then, using 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.

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 from the areas more exposed (Bustos et al., 2016). However, this prediction is inconsistent with my findings that those areas experienced an increase in population, suggesting that this is not the major mechanism through which the policy operated.

The BG increased the incentives to intensify wheat production also through the implementation of tariffs in wheat. Thus, it is of interest to understand whether, conditioning on technological progress, the tariffs would have been sufficient to stimulate human capital accumulation. To examine

[10] 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). 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).

[11] Further, I find that more exposed cohorts are also more likely to be employed in manufacturing, which is consistent with the results across municipalities over time.

this point, I split my measure of the potential returns from the BG in the potential returns due to technological progress and the potential returns due to the tariff-induced increase in the wheat price. Then, I estimate the effect of these two variables on human capital. I find that, while technological progress stimulated human capital accumulation, the higher potential returns from the increase in wheat price had limited effects.

The different effects of the policy documented for technical change and price increase can shed light on the role of agricultural productivity in economic development. The positive effects of technical change point toward the skilled-bias nature of the comprehensive stimulus to technological progress determined by the BG, underlining the importance of human capital as a channel through which rising agricultural productivity can have long-lasting positive effects. The limited effect of the price increase on education indicates that the increase in factors' returns in agriculture does not stimulate human capital accumulation and economic development.

In addition, the heterogeneous effects of the BG can shed light on the consequences of transitory protectionist interventions on economic development. While conventional economic wisdom indicates that deviations from free trade are sub-optimal, arguments in favor of industrial policies suggest that transitory protection can have positive effects (Hausmann and Rodrik, 2003; Stiglitz and Greenwald, 2014). In protecting the wheat industry, the BG determined technological progress in places where the new wheat production technologies were more profitable, ultimately fostering human capital accumulation and industrialization in those areas. Instead, places that could only benefit from the tariff-induced increase in wheat prices did not experience a significant enhancement in education and industrial development. This contrast underlines the relevance of skilled-bias technical change as a mechanism through which protectionist interventions may influence long-run development.

I perform several checks to assess the robustness of the results. Specifically, estimates are robust to considering a host of potentially confounding factors related to this historical period, such as land reclamation of areas historically affected by malaria, the foundation of new cities, the effect of limiting migration to cities above 25,000 inhabitants (Bacci, 2015),[12], the presence of railroads, and differences in land distribution (Galor et al., 2009; Adamopoulos and Restuccia, 2014). Furthermore, I find little 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.[13] Finally, I investigate whether wheat suitability is conducive to economic development beyond Italy.[14] I find that, while across European regions outside Italy the estimated effect of wheat suitability on economic development is negative, within Italy it is positive. This result suggests that, in the absence of human capital augmenting agricultural technological progress, wheat suitability is not conducive to economic development.

The paper is structured as follows. 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. Last section concludes.

2 Related Literature

Based on the experience of England and other western societies, several scholars have emphasized the importance of a rise in agricultural productivity as an important condition for urbanization and industrial development

[12] It has been noticed that this policy was not enforced (Treves, 1980).

[13] 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).

[14] On the importance of geography on economic development see Diamond (1998); Gallup et al. (1999); Pomeranz (2009).

(Rostow, 1960; Nurkse et al., 1966). [15] In particular, it has been argued that rising agricultural productivity can help solve the "food problem" (Schultz, 1953) and enhance the demand for manufacturing goods (Murphy et al., 1989; Gollin et al., 2002). Moreover, recent studies investigate the effects of rising agricultural productivity from an empirical point of view (Nunn and Qian, 2011; Hornbeck and Keskin, 2014). In particular, Bustos et al. (2016) underline the importance of factor bias technical change in agriculture for the transition to industry. This paper complements this view emphasizing the importance of skilled-bias technical change in agriculture and providing evidence of its long-run beneficial effects.

In contrast, while Clark et al. (1998) and Allen (1999) minimize the importance of rising agricultural productivity for industrialization, Lewis (1954); Kaldor (1966) and Harris and Todaro (1970) indicate the rise in manufacturing productivity as the main driver of the transition to urban centers.[16] Furthermore, rising agricultural productivity may enhance comparative advantage in this sector, crowding-out the non agricultural sectors (Mokyr, 1976; Field, 1978; Wright, 1979). My findings of the limited effect of a rise in the returns to factors in agriculture is consistent with these views and with works illustrating that Hicks-neutral increases in agricultural productivity are not beneficial for human capital accumulation (Galor and Mountford, 2008) and the development of non-agricultural sectors (Matsuyama, 1992; Foster and Rosenzweig, 2004).

This work also relates to the literature studying the effects of temporary protection. Existing works in trade (Melitz, 2005; Rodriguez-Clare and Harrison, 2010), and on the infant industry hypothesis (Juhász, 2014), emphasize the role of within-sector spillovers. This paper complements this literature as it focuses on the importance of spillovers *across* sectors, from agriculture to industry, in understanding the effects of protection-induced technological

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

[16] Alvarez-Cuadrado and Poschke (2011) illustrate that in early stages of the transition to industry the rise in manufacturing productivity is a more relevant force of industrialization, while the increase in agricultural productivity becomes relevant in later stages.

progress.[17] Furthermore, while learning spillovers have been highlighted as an important mechanism through which temporary protection operates (Stiglitz and Greenwald, 2014), this paper highlights the importance of human capital spillovers. Moreover, my findings of the limited effect of the tariff-induced price increase in wheat lend further credence to the finding that, in the absence of technological improvements, protectionist interventions are not conducive for human capital accumulation (Bignon and García-Peñalosa, 2016).

Finally, the study of the long-term effects of the BG on economic development, conditioning on deep-rooted factors,[18] can contribute to out understanding of the long-term effects of policy interventions (Rosenstein-Rodan, 1943; Murphy et al., 1989; Kline and Moretti, 2014). In particular, given the significant urban-rural labor misallocation that characterizes developing economies (Gollin et al., 2013), ultimately determining significant differences in living standards (Restuccia et al., 2008; Young, 2013), my findings points to the role that policy can have in stimulating industrialization through skilled-bias technical change in agriculture and the associated increase human capital investment.

3 Historical Background

3.1 The Origins of the Regime

In 1914, Benito Mussolini formed a movement called "Italian Fasci of Combat." As described by Lyttelton (2004), the movement was composed by a group of men coming from different parties "brought together by their advocacy of Italy's entry into the war". The movement was rooted in the principle of interventionism and "not to any previously formed body of doc-

[17] The relevance of cross-sector linkages for economic development is also emphasized by Kremer (1993); Jones (2011); Fiszbein (2014); Dell and Olken (2017), among others.

[18] On the relevance of deep-rooted factors in comparative economic development, see Galor (2005); Nunn (2009); Spolaore and Wacziarg (2013).

trine, social philosophy or economic interest."[19]

The *Fasci* ran in the elections of 1919 receiving a number of votes that was insufficient to give them any deputies in the Parliament. Despite the initial disappointment with the electoral outcome, Mussolini sought for larger support across all social classes and formed the "National Fascism Party" in 1921. The party ran in the elections of that year and Mussolini entered the Parliament.[20]

After World War I, Italy was characterized by political instability and continuing violent clashes between socialists, communists and fascists. In 1922, Mussolini took advantage of this political instability and, with a militia composed by 30000 units, organized a *coup d'état*: the so called March on Rome. For reasons that are still debated among historians, King Vittorio Emanuele III did not oppose his military power to the Fascist militia, instead he gave Mussolini the opportunity to became head of the Government.

The newly formed government was declared a dictatorship in 1925. In a famous speech in December 1925, the *Duce* declared the main principle of the Regime: "I consider the Italian nation in a permanent state of war". As emphasized by Lyttelton (2004), the Fascist economy was based on the"primacy of policy over economics, the primacy of war over politics." Based on this view, the Italian economy had to be self sufficient in the production of primary goods such as wheat.

3.2 The *Battle for Grain*

When the dictatorship was declared, the balance of payment was in deficit and the value of wheat imports accounted for about one sixth of total imports

[19] Interestingly, from a financial point of view Mussolini was supported by foreign powers in his start in politics (Kington, 2009).

[20] Mussolini took advantage of the weakness of right parties (*Destra Storica*) that characterized the post-war period. In particular, in an attempt to strengthen the *Destra*, Giolitti formed large coalitions (*Blocchi Nazionali*) that allowed small extremist parties (such as the *Fasci*) to enter the Parliament (Leoni, 1971).

(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 shortage of primary goods associated with it, was a fundamental motive that induced Mussolini to increase domestic wheat production and achieve self-sufficiency.

At the time of the advent of the fascist regime, Italian agriculture was on average very primitive[21] (Lorenzetti, 2000). In particular, seed selection was basically absent and there was scarce use of fertilizers and machines. In addition, 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 achieve self-sufficiency in the production of this primary crop.

A first set of interventions was introduced to stimulate wheat yield. To solve the seeds problem, public investments were made in R&D for the selection of species of wheat that could maximize yield per hectare (Serpieri and Mortara, 1934). In particular, the Regime financed Nazareno Strampelli, a scientist who devoted his life to the creation of improved varieties of wheat. He was the first to apply Mendel's laws to plants and wheat breeding, and his seeds were characterized by rust resistance, early maturity, and short straw. After WWII, these seeds will be used in other countries such as Argentina, China, and Mexico. Furthermore, they will be instrumental for the creation of the high-yielding varieties developed by Borlaug, ultimately contributing to the Green Revolution (Salvi et al., 2013).

In addition to technical change given by the availability of new seeds, there were additional interventions targeted to improve productivity. Wheat producers were subsidized for purchasing agricultural machines, such as tractors and threshers. At the same time, the Regime implemented special regulation aimed to reduce the price of fertilizers. As a result, the use of commercial

[21] However, significant differences across regions existed. For instance, agriculture on the Padania plane was typically more advanced than the latifundia of the South. To take into account these preexisting differences across regions and provinces, in the empirical specification I exploit within-province variation.

fertilizers rose from 1,458,279 tons in 1913 to 2,196,876 tons in 1929 (Hazan, 1933). Finally, prizes were offered to farmers with the highest wheat yields per hectare.[22]

A key aspect of the BG was related to the spread of information about these technical changes and the stimulus they dad on education. The "Traveling Chairs of Agriculture" (*Cattedre Ambulanti di Agricoltura*) were instituted in order to spread agricultural knowledge. They played a key role in the professional development of the agricultural sector and the development of farmers professional education (D'Amico, 2015). In addition, "progress was made in the field of agricultural education. Through the work given in practical agricultural schools and in universities, agriculture has come very much into vogue" (Hazan, 1933). The spread of information about the new technologies was further advertised by the intense and constant propaganda exploited by the Regime.

In order to increase prices of wheat, the regime implemented a significant tariff on wheat imports. Figure 20 depicts the magnitude of this intervention. As the figure makes apparent, over the 30's the tariff increased price of imported wheat by more than 100%.

A the same time, to further protect domestic wheat producers, the Regime also adopted compulsory milling, which was imposed on domestic producers that used wheat as an input in their production process. In particular, this law required that at least 95% of the wheat used in any production process had to be purchased from domestic producers. This measure would maintain high domestic demand of wheat, in turn having a positive effect on wheat price level.

An additional intervention was related to wheat storage. In particular, during the season of wheat harvest, the increase in seasonal supply was

[22] As discussed in Serpieri and Mortara (1934), the prizes were both at national and local level. For instance, prices were offered at the level of agrarian zones. Such zones where composed by an average of 10 municipalities based on similarity of geographic characteristics. This aspect highlights that incentives to produce wheat were given even at a very local level.

pushing domestic price down, thus reducing the effectiveness of the tariff. Therefore, in order to keep the supply less cyclical, farmers were compensated when storing wheat in silos during the wheat season. This measure had an additional positive effect on domestic wheat price.

The set of interventions described were adopted to achieve higher domestic price of wheat and stimulate domestic wheat production. These policies were overall successful as, in addition to an immediate spike in domestic price of wheat (see figure 21), real price of wheat over the years of the policy remained on average 20% higher than before (see figure 22).[23]

As a result of the set of interventions, wheat yield per hectare increased by more than 25% over the years of the policy.[24] At the same time, as depicted in figure 23, wheat imports decreased substantially while domestic wheat production went up by roughly the same magnitude (see figure 26,).[25][26] During the BG, the adoption of agricultural machines increased by 85%[27]. Similarly, the adoption of fertilizers saw unprecedented increases(Cohen, 1979).

[23] This number refers to the comparison of average real price of wheat over the years from 1919 to 1924 versus average real prices over the years from 1925 to 1930 (growth rate 19.2%). After 1930 there is evidence of direct price control from the government, however considering average real price of wheat over the period 1925 to 1938 real price was higher by more than 25.3%. Prices are normalized by the Consumer Price Index by Malanima (2002).

[24] 25% is the percentage difference between average output per hectare over the years from 1921 to 1924 and the average from 1925 to 1938. Data are from ISTAT time series of land devoted to wheat (available from 1921) and quantity of wheat at national level.

[25] Over this period, manufacturing-related products did not exhibit a downward trend. Figure 24 shows that imports for steel and iron products did not decrease. Figure 25 illustrates that oil and related products display increase in imports over this period of time. At the same time, while domestic wheat production was increasing, corn production remained did not (see figure 27). These patterns lend credence to the effectiveness of the BG in achieving self-production of wheat.

[26] Between 1928 and 1929, the United States experienced a significant reduction in the price of wheat that pushed international wheat prices downward. As a result, the negative trend in wheat imports is characterized by a temporary halt over these two years. The reaction of the Italian government was given by an immediate and substantial increases in the tariff (Lorenzetti, 2000, p. 262), which is also evident in figure 20.

[27] In the second half of the twenties, the Italian company for agricultural machines, Landini, became leader in the development of tractors. One of its best success was in 1935 for its Landini Vélite, where the name Vélite comes from the title that Mussolini gave to those who had outstanding wheat production during the *Battle for Grain* (Benfatti, 2000).

4 Data

Agriculture data are compiled from the census of agriculture in 1929 at the level of Italian municipalities.[28] Figure 28 shows the coverage of the 94 books that compose the census of agriculture in 1929. This significant inquiry was undertaken by the regime four years after the adoption of the BG. As described in the historical literature, the BG was a productivity oriented policy (Serpieri and Mortara, 1934; Profumieri, 1971; Cohen, 1979; Segre, 1982). In other words, it was introduced to achieve an increase domestic wheat production through an increase in wheat yield, rather than an increase in land devoted to wheat at the expense of other crops. Therefore, the natural way to measure the increase in wheat productivity due to the policy is to look at the increase in wheat yield, measured as tons of wheat per hectare per year, before and after the introduction of the policy.[29]

The census of agriculture reports yield per hectare in 1929 (y^w_{29}), thus four years after the introduction of the BG, and average yield per hectare over the years 1923-1928 ($\bar{y}^w_{23-28}$). Since the policy was introduced in July 1925, and before the wheat seeding period of that year, the first harvest after the adoption of the policy was in 1926.[30] Therefore $\bar{y}^w_{23-28}$ covers three years before and three years after the introduction of the policy. As a result of it, looking at the increase in wheat yield, $\Delta y^w \equiv (y^w_{29} - \bar{y}^w_{23-28})$, would underestimate the change in agricultural productivity due to the BG. (See Appendix F for a formal proof).[31] In addition, the actual increase in wheat

[28] Municipalities (*Comuni*) correspond to LAU level 2 (formerly NUTS level 5) in the Eurostat nomenclature.

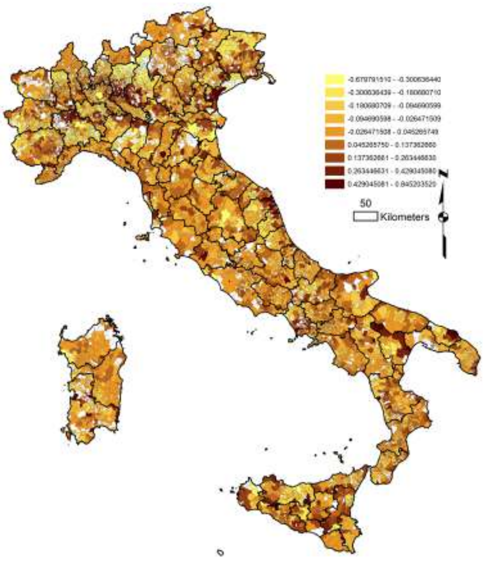
[29] Variation in wheat yield over the first years of the policy is observed for 92 % of the municipalities in the sample. Among those who had constant wheat yield, only 2% of the sample had a constant wheat yield over the period considered. This result further suggest that the BG affected agricultural productivity in wheat production in the country as a whole.

[30] As described in the Census of Agriculture of 1929, in the Italian peninsula the seeding period for wheat goes from September to the beginning of January.

[31] The variable of interest can be written as the sum of the latent unobserved variable of interest, namely measured without error, and a measurement error term ($\Delta y^w = (y^w_{29} - y^w_{23}) - (\bar{y}^w_{23-28} - y^w_{23}) \equiv \Delta y^*_w - \xi$). Given that $Corr(\Delta y^*_w, \xi) \neq 0$, the observed variable of interest is affected by non classical measurement error. Dealing with non classical

yield is observed until 1929, thus a decade before the end of the BG, which further underestimates the increase in wheat yield due to the BG.

Figure 1: The Increase in Wheat Yield 1923-1929



Notes: The map depicts the increase in wheat yield per hectare over the years 1923 - 1929 after controlling for province fixed effects

Figure 1 illustrates a map of the increase in wheat yield across Italian municipalities. Figure 2 depicts the increase in wheat yield per hectare over the first years of the BG. In the figure, wheat yield is expressed in real terms of the local currency (*lire*) so that it can be compared to the change in yield per hectare for other crops, depicted in figure 3. The figures highlight that over the period of the policy there was an increase in wheat yield but not in other other crops, ultimately suggesting that the policy was effective in stimulating wheat yield.

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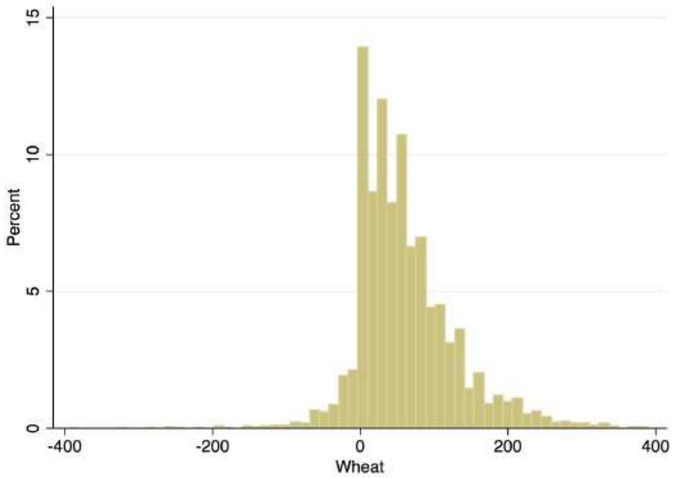
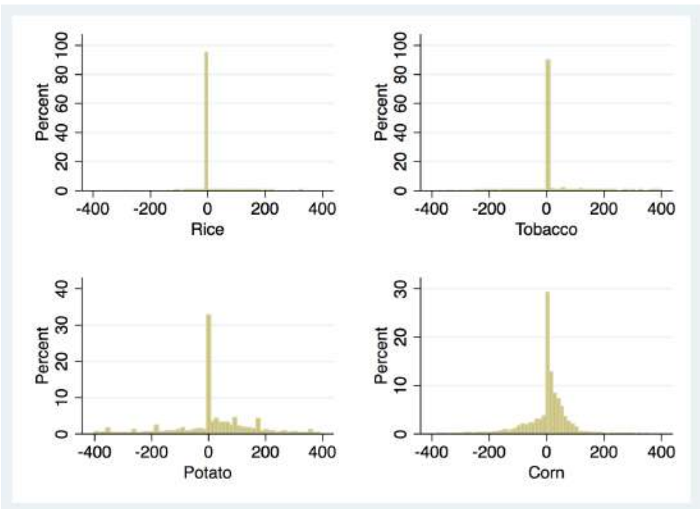
measurement error in continuous variable is often based on the use of an auxiliary data set containing correctly measured data (Chen et al., 2005a,b). Unfortunately, auxiliary historical data are not available for this historical period. Therefore, I employ variation in potential yield of wheat and other crops from the FAO's GAEZ v3 project to construct a variable that captures the potential exposure to the policy the BG.

Figure 2: Increase in Output per Hectare 1923-1929 for Wheat (in 1911 *lire*)



Notes: The above figure depicts the increase in wheat yield per hectare over the years 1923 - 1929 evaluated at real prices of 1919. Namely, the variable represented is $\Delta\tilde{y}_i^w * P_{19}^j$ where $\Delta\tilde{y}_i^j$ is the change in wheat yield per hectare in municipality i over the years 1923-1929, and P_{19}^w is national real price of wheat in 1919, base year 1911 *lire*. See main text and appendix for variable definition and sources.

Figure 3: Change in Output per Hectare 1923-1929 for Selected Crops (in 1911 *lire*)



Notes: The above figure depicts the change in yield per hectare over the years 1923 - 1929 evaluated at real prices of 1919 in real terms for selected crops. Namely, the variable represented is $\Delta\tilde{y}_i^j * P_{19}^j$ where $\Delta\tilde{y}_i^j$ 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 technological progress in agriculture on industrialization and economic development. Specifically, I analyze the technological improvements in wheat production that was determined by the BG. In section 5.1, I employ economic outcomes before and after the policy to investigate the emergence of a significant and persistent relation between the increase in wheat productivity over the years of the BG and economic development. Then, to examine the presence of a causal link, in section 5.2, I exploit as exogenous sources of variation the timing of the policy together with the potential returns from adopting the new wheat production techniques as determined by geographic conditions.

5.1 Increase in Wheat Yield and Development

In this section, I document that areas where wheat yield increased over the period of the policy experienced significant expansions in economic activity and industrialization. Interestingly, this positive relation emerged only after the introduction of the BG and persisted until today, while it was absent before the policy.

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

$$Y_{it} = \alpha_i + \alpha_{ct} + \beta_t \Delta y^w_{23-29,i} + \epsilon_{it} \quad (1)$$

Where Y_{it} represents is 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; $\Delta y^w_{23-29,i}$ is the increase in wheat yield over the years 1923-1929 in municipality i. The coefficients 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 $\Delta y^w_{23-29,i}$.[32] Given that β_t can change over time, my assumption is that β_t is approximately zero for the periods before implementation and positive afterwards.

Substantial differences in economic development across Italian regions were already significant before the BG and the debate about the 'Southern Question' begun as early as the 70's of the nineteenth century.[33] 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.[34]

The focus on within province variation takes into account unobserved factors - for example culture or informal institutions - that vary across provinces and have been indicated as determinants of the Italian regional imbalances. In addition, province fixed effects take into account potential differences in the data collection process, which was performed at the level of historical provinces. Finally, given that deep rooted factors such as geography, culture, and diversity have been shown to be major determinants of economic prosperity even at sub-national level, I control for fixed-effects at the level of the municipality. This approach ensures that time-invariant characteristics are taken into account.

Figure 4 depicts the coefficients from estimating equation 1, using as an outcome variable the natural logarithm of population, and the 95% confidence intervals based on robust standard errors clustered at the province level.[35] The estimated coefficients fully comply with the hypothesis of a

[32] The reference year used in the analysis is 1911 because it is the first year for which I have data on manufacturing population. The results are not affected by the choice of the reference year.

[33] See, e.g., Daniele and Malanima (2011), Zamagni (1993), Felice (2013).

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

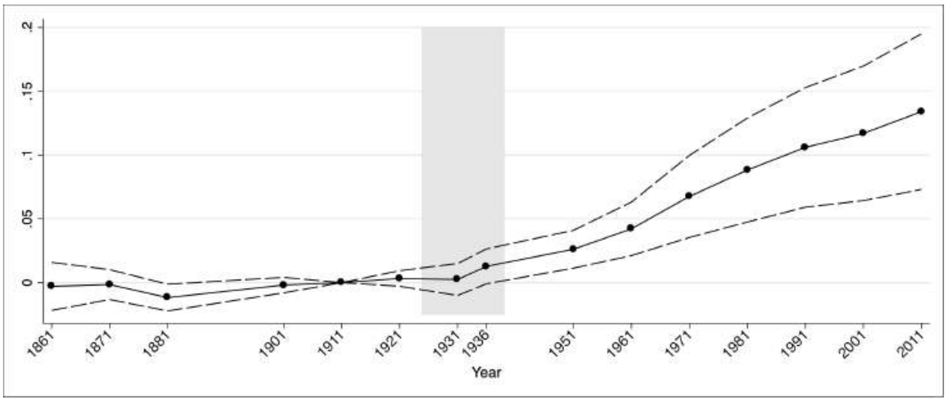
[35] This approach takes into account serial correlation within the cluster and over time (Angrist and Pischke, 2008). Using Conley (1999)'s methodology with cutoffs at 50, 100, and 200 kilometers, I estimate standard errors that are smaller in magnitudes than the ones estimated using clustered standard errors. Results available upon request.

positive effect of the policy on economic development. In particular, the estimates are small in magnitude and not statistically significant in the decades before the introduction of the policy. Then, the estimates become positive and statistically significant in 1936, thus 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 triggered a cumulative process of development that unfolded over the course of the twentieth century, period in which the contribution of the agricultural sector to output formation diminished.

Figure 5 depicts the coefficients from estimating equation 1 using as an outcome variable the share of population in manufacturing and the 95% confidence intervals. The figure shows that municipalities were wheat yield increased due to the BG experienced an expansion in industrial development from 1951 onward, thus more than a decade after the end of the BG. While several historical events that characterized the history of Italy over this period may explain the delayed emergence of this statistical relation, the result is also consistent with the hypothesized effect of the BG on human capital accumulation, which was conducive for industrialization in later stages. The estimated coefficient for 2001 indicates that municipalities experiencing a one standard deviation increase in the increase in wheat yield over the period of the policy are characterized by a 13% larger population and a 8.5% larger share of people working in the manufacturing sector, relative to 1911.

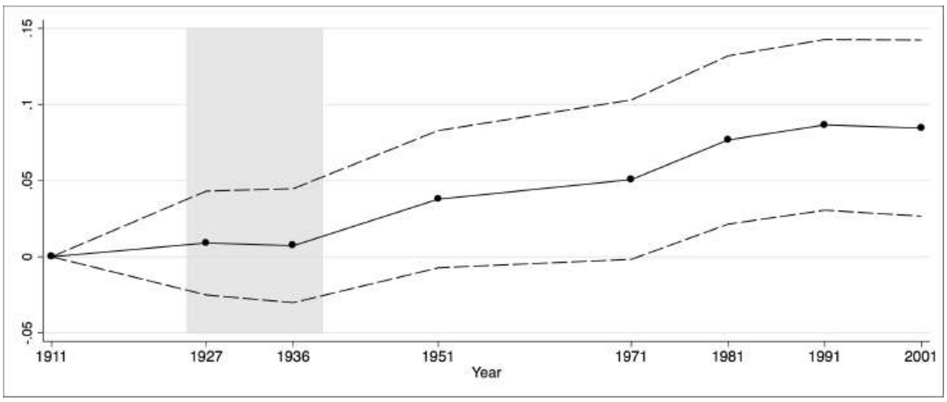
Given the use of variation within province, the estimates shown in this section are based on the comparison between municipalities very close to each other and thus very similar under several dimensions. Nevertheless, reverse causality may be a threat to identification. Therefore, the following section develops an empirical strategy aimed to investigate the causal link between the BG and economic development.

Figure 4: Increase in Wheat Yield and Population Density: Flexible Estimates



Notes: The above figure depicts the coefficients estimates of (1) from regressing population density measured in natural logarithms on the increase in wheat yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression that include municipality fixed effects and province specific time fixed effects. See table A1 for the estimated coefficients. See main text and appendices for variable definition and sources.

Figure 5: Increase in Wheat Yield and Industrialization: Flexible Estimates



Notes: The above figure depicts the coefficients estimates of (1) from regressing the share of population in manufacturing on the increase in wheat yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression that include municipality fixed effects and province specific time fixed effects. See table A1 for the estimated coefficients. See main text and appendices for variable definition and sources.

5.2 Empirical Strategy: the Potential Revenue Index

5.2.1 The Construction of the Index

In this section, I employ geographic variation to construct a novel variable that captures the potential returns from adopting the more productive inputs advanced by the policy together with the tariff-induced increase in wheat prices. The need for exogenous sources of variation to identify the causal effects of the BG on economic development is mainly 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 that 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 and implying reverse causality. In order to assess these concerns, I exploit geographic suitability for the new wheat production technologies stimulated by the policy.

The BG determined a technical change in wheat production due to the availability of improved wheat seeds together with subsidies to machines and fertilizers. At the same time, the wheat tariff determined a positive shock in national price of wheat relative to other crops, further enhancing farmers' incentives to intensify wheat production through the adoption of more modern techniques. To empirically mimic this change in incentives for farmers, I construct a variable that combines two sources variation: the shock in national price of wheat caused by the BG, together with the *potential* increase in wheat yield due to the adoption of the new inputs as determined by geographic characteristics.

To construct my variable of interest, I use two sources of data. First, I employ national prices for wheat and major crops. The Italian Statistical Office (ISTAT) provides nominal price data of the major crops over the years 1861-2010.[36] I convert prices in real terms using the Consumer Price Index

[36] Price data are from ISTAT (*http://seriestoriche.istat.it* - Tavola 21.1) last access November 2015.

by Malanima (2002).[37] The second source of data is from the Food and Agriculture Organization of the United Nations (FAO)'s Global Agro-Ecological Zones (GAEZ) v3.0, which provides measures of production capacity for several crops based on geographic and climatic characteristics.

Production capacity is estimated assuming different input levels (low, intermediate, and high).[38] In particular, the estimated potential yield with low inputs levels are based on a model that considers "labor intensive techniques, and no application of nutrients, no use of chemicals for pest and disease control and minimum conservation measures". These conditions are very similar to the obsolete wheat production techniques used in Italy before the BG (Lorenzetti, 2000). The estimated potential yield with intermediate input levels are based on a model that considers production as "based on *improved varieties*, on manual labor with hand tools and/or animal traction and some *mechanization*, is medium labor intensive, uses some *fertilizer* application and chemical pest disease and weed control" (emphasis added). Thus the increase in inputs levels is centered around the inputs that were stimulated by the BG: improved seeds, mechanization, and fertilizer.[39] The improvements in the potential wheat yield from low to intermediate levels represents the ideal source of cross-sectional variation needed to identify areas who had larger potential returns from adopting the BG.

Using the two sources of data described above, I construct the Potential Revenue Index (PRI): a measure of the potential revenues of wheat relative to competing crops in a given year and for a given level of inputs.

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

$$PRI_{0,i} = \sum_c \frac{\bar{p}_0^w \hat{y}^w_{c,(low)}}{\sum_{j \in \mathcal{C}_c} \bar{p}_0^j \hat{y}^j_{c,(low)} / |\mathcal{C}_c|} dP(c|c \in i) \text{ where } w \notin \mathcal{C}_c \qquad (2)$$

[37] The CPI by Malanima is based on the ISTAT index and the index by Fenoaltea (2002)

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

[39] Production with high inputs level is instead based on the most modern agricultural techniques available today. Thus they would not appropriately represent the Italian technological standards from the first half of last century. Results are robust to the use of high inputs level rather than intermediate (see appendix table B6).

where $\bar{p}_0^j$ is the average national real price of crop j over the years before the policy (i.e. $t = 0$).[40] $\hat{y}_{c,(low)}^j$ represents the potential yield per hectare of crop j with low inputs in cell c (where $j = w$ depicts wheat).[41] $\mathcal{C}_c$ is the set of productive crops in cell c that are not complementary to wheat production.[42] Then $P(c|c \in i)$ is given by the intersection between area of cell c and area of municipality i.

The numerator of equation 2 represents the potential revenues per hectare from producing wheat at the national prices before the policy and with low input level. The denominator is the average potential revenues from the productive crops that are potentially alternative to wheat, again with low inputs and pre-policy prices. Thus the PRI represents the potential revenues per hectare from producing wheat relative to the forgone revenues from competing crops, evaluated at low level of inputs and pre-policy prices.[43]

The BG determined a significant increase in wheat prices, due to protectionist measures, and technical change in wheat production. In other words the policy increased the incentives to intensify wheat production, changing the returns from producing wheat relative to other crops. To capture this change in incentives, I calculate the PRI taking into account the new national prices and the new inputs for wheat production. Thus, I construct the PRI

[40] Given that the policy was implemented in 1925, the years considered before the policy are between 1919 and 1924. I do not employ priced before 1919 because during World War I (1914-1918) prices do not necessarily reflect market forces. The rationale of taking average real prices over the years before the policy is to prevent that fluctuations of prices in one specific year to drive the analysis.

[41] For a description of data and sources, see appendix E

[42] Productive crops in a cell are defined as the set of crops characterized by potential revenues per hectare above one lire at 1911 prices. In the absence of this consideration, the average at the denominator of the PRI may be affected by values very close to zero which would inflate the PRI. The results are very similar if I employ alternative definitions of productive crops to construct the index, as illustrated in tables B8 and B9 in the appendix.

[43] Crops that are competing with wheat are Citrus, Oats, Olives, Potatoes, Tomatoes. Results are robust to the inclusion of complementary crops, see tables B6 and B7. Complementary crops are legumes, maize, rice, and tobacco (Sulieman and Tran, 2015; Allen, 2008; Berzsenyi et al., 2000) and also indicated in the Census of Agriculture 1929, and Enciclopedia Treccani 1936 (see `http://www.treccani.it/enciclopedia/tabacco_(Enciclopedia-Italiana)`, last access April 2016).

to capture the profitability from producing wheat after the introduction of the BG. Namely, I compute:

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

where p_1^j is the price of crop j after the introduction of the policy ($t = 1$).[44] $\hat{y}^w_{c,(int)}$ is the potential wheat yield per hectare with intermediate inputs in cell c.[45]

Finally, to measure the the potential returns from wheat, I consider the growth in the PRI. Namely,

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

which is the growth in the potential revenue index due to the technological improvements in wheat, as well as the price shock due to the protectionist interventions. Figure 6 display a map of this variable.

Having built my measure of the intensity of the exposure to the BG based on the potential returns from the advanced technologies and the price shock, I turn to investigate whether this variable captures meaningful variation in the actual increase in wheat yield. Table 1 depicts the estimates of a regression of the increase in wheat yield over the years 1923-1929 on the increase in the log of the in the PRI, while figure 7 depicts the unconditional relationship between these two variables.[46]

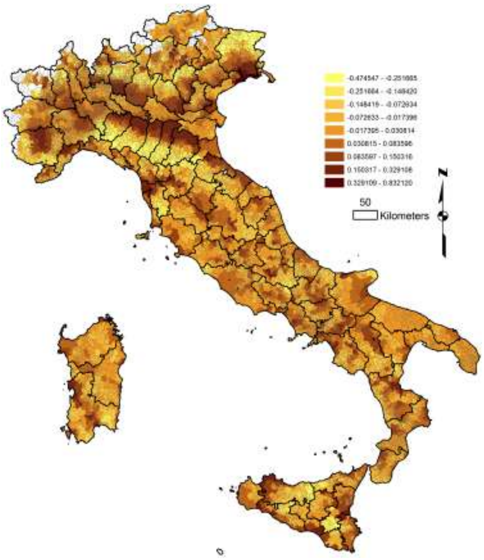
Column 1 shows the effect of land suitability for wheat on the increase in

[44] Specifically, the years considered are from implementation, 1925, to 1929. Thus right before the Great Depression.

[45] Although the intermediate level if 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 high level of inputs instead of the intermediate one. See appendix tables B6 and B7.

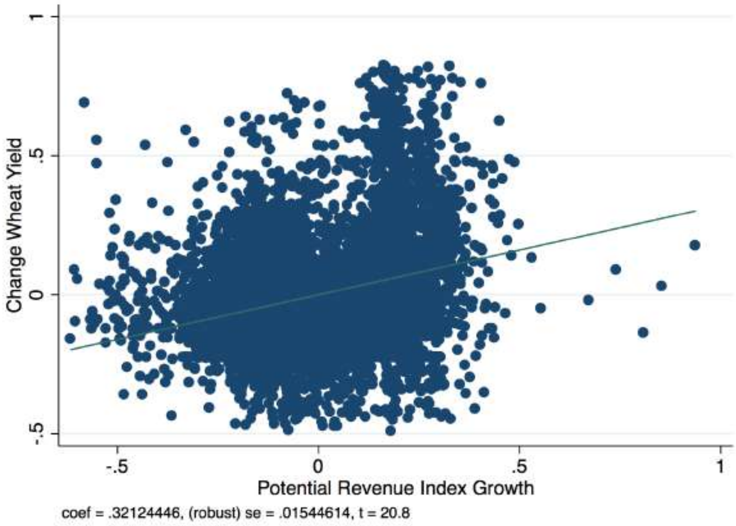
[46] Under the assumption of risk averse farmers (Hiebert, 1974; Foster and Rosenzweig, 2010), the uncertain returns from the new wheat production technologies and the lower diversification due to farmer's investment in this crop can rationalize the linear-logarithm relation.

Figure 6: The Potential Returns from the *Battle for Grain*



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

Figure 7: The Effect of PRI Growth on the Increase in Wheat Yield



wheat yield at the time of the policy, conditioning on province fixed effects.[47] 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 were instrumental for intensifying wheat production given the incentives of the BG.

Column 2 adds my index for the exposure to the BG. The coefficient is positive and highly significant, which suggests that, in addition to the initial geographic advantage in wheat production given by geographic suitability for wheat, my variable captures the additional increase in wheat yield due to technical change.

Table 1: The Predictive Power of the PRI. OLS

	(1)	(2)
Dependent Variable: *Δ Wheat Yield 1923-1929*		
$\Delta lnPRI_{(1919-29)}$		0.1381***
		[0.042]
Wheat Suitability	0.3126***	0.2636***
	[0.074]	[0.066]
province FE	Yes	Yes
F-statistic (K-P)	-	10.91
Observations	6,662	6,662
Adjusted R^2	0.443	0.448

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 and province fixed-effects. The Kleibergen-Paap's F-statistic refers to $\Delta lnPRI$. Robust standard errors clustered at the province level in brackets. Observations are at the municipality-level. See main text and appendices for variables definitions and sources. *** indicates significance at the 1%-level, ** indicates significance at the 5%-level, * indicates significance at the 10%-level.

To gain a better understanding of the source of variation embedded in the PRI, I reconstruct the index using alternative specifications. Then, I

[47] Land suitability for wheat is the potential wheat yield per hectare with low inputs from FAO GAEZ.

investigate their correlation with the actual increase in wheat yield over the years of the policy. Results are depicted in table 2. Column 1 simply depicts the baseline formulation of the PRI for comparison. In column 2, I employ a version of the index where technology is constant at the low level of inputs and only prices shock is considered. Column 3 depicts the same regression using as a source of variation the index of interest where only technological level changes and 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. However, 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, as the increase in wheat prices gave additional incentives to produce wheat and adopt the new technologies. Column 4 and 5 employ two alternative formulations of the PRI. 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, suggesting that the index is a valid measure of the potential returns to the interventions of 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.[48]

[48] 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, 2015). Further, Glaeser et al. (1995) and Gonzalez-Navarro and Turner (2016) use population data in contemporary periods as a measure of urbanization.

Table 2: 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 main text and appendices for variables definitions 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.

The identifying assumption is based on the argument that the interaction 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. To support this assumption, it is important to demonstrate 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:

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

Where Y_{it} represents population density in logs, 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; $\mathbf{X}$ represents 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 percentage difference in population associated with a one standard deviation increase in the growth of the PRI between year t and a base year.[49] Note that the introduction of municipality fixed effects takes into account time-invariant characteristics at the level of municipalities. province-year fixed effects control for differences in time patterns across provinces.

Estimates are robust to the inclusion of flexible controls. During the period of study, significant progress in malaria eradication was made, in particular through land reclamation and the introduction of DDT (Snowden, 2008). Malaria eradication might be correlated with changes in agricultural productivity and economic development. To take into account this potentially confounding factor, I flexibly control for historical presence of malaria.[50]

[49] I employ 1911 as a base year because is the first period in which I observe manufacturing employment data. The qualitative results are unchanged if a different base year is employed. The baseline empirical model shown in the following sections is unaffected by the choice of the base year.

[50] This variable takes value one if the municipality was affected by malaria in 1870. Data are from a map of malaria presence in 1870 by Torelli (1882) that I have digitized. See appendix for additional details.

Given that the Fascist regime emphasized the importance of the agricultural sector in its propaganda, it is possible that places naturally more suitable for agriculture may have had economic advantages that were independent from the BG. To take into account this element, I flexibly control for suitability for agriculture measured by the Caloric Suitability Index (CSI) developed by Galor and Özak (2014). The index measures the average calories per hectare that can be produced based on geographic conditions.[51]

To take into account the significant geographic diversity that characterizes the Italian territory, I flexibly control for the standard deviation of elevation in the municipality. Finally, to correct inference, I cluster the standard errors at the province level. So that I allow the error term to be spatially correlated across municipalities within provinces and serially correlated over time.

Figure 8 depicts the estimated coefficients using as an outcome the natural logarithm of population density (coefficients are reported in table A2).[52] 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). Consistently 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 effect persisted through recent times, when the contribution of agriculture to output formation was marginal.[53] The coefficient for 2011 is approximately 21%, meaning that a one standard deviation increase in the growth of the PRI can explain higher population density in 2011 by 21%, relative to 1911.

Figure 9 illustrates the estimates using as an outcome the share of the population working in manufacturing. 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 determined an increase in industrialization

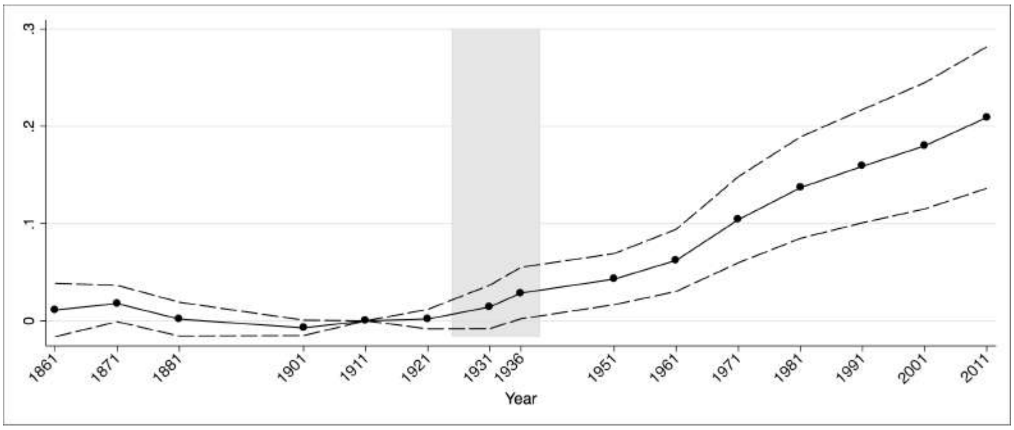
[51] It has been shown that the CSI is a measure of soil fertility superior to those previously used in the literature (Galor and Özak, 2015).

[52] Note that the Census of Population for the years 1891 and 1941 was not taken.

[53] For instance in 2014, value added in agriculture was 2.2% of GDP (source: ISTAT).

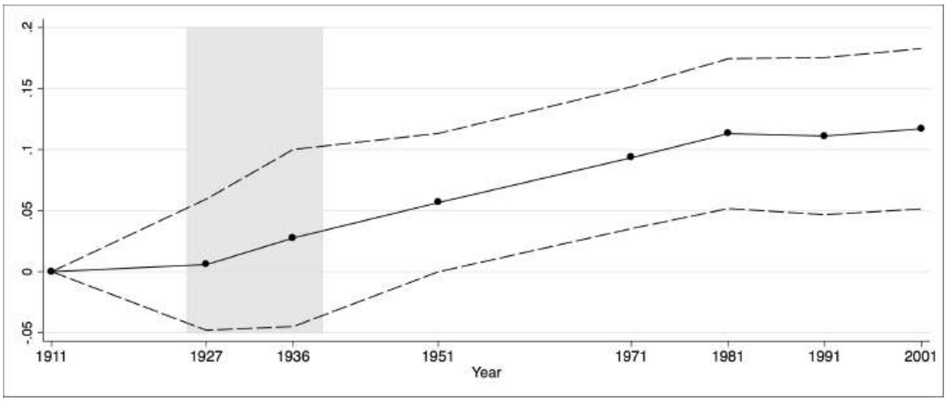
by 12% of a standard deviation in 2001, relative to 1911.

Figure 8: The PRI and Population Density



Notes: The above figure depict the coefficients estimates of (5) for the effect of growth in the Potential Revenue Index on population density measured in natural logarithms. Estimates are from the a regression that includes municipality fixed effects, province specific time fixed effects, and flexibly controls for latitude, terrain ruggedness, and historical presence of malaria. See main text and appendices for variable definition and sources.

Figure 9: The PRI and Manufacturing: Flexible Estimates



Notes: The above figure depicts the coefficients estimates of (5) for the effect of growth in the Potential Revenue Index on share of manufacturing population, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression that include municipality fixed effects, province specific time fixed effects, and flexibly controls for land suitability for wheat, and for agriculture (CSI), terrain ruggedness, and historical presence of malaria. See main text and appendices for variable definition and sources.

5.2.3 Baseline Specification

In the following, I turn to estimating a more parsimonious model. This model has at least two advantages. First, it allows the estimates to be independent of a reference year. Second, it allows for formal tests of placebo timings of the policy. In particular, I estimate the following equation,

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

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, year in which the policy was implemented. $\mathbf{X}$ 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 as a measure of ruggedness.

Table 3 depicts the estimates of the baseline specification with population density as an outcome variable. Consistently with the hypothesis of a positive effect of the BG on long-term economic development, the coefficient is positive and statistically significant across all specification. Note that in all specifications I control for province by time fixed-effects and municipality fixed effects. In addition, in column 1, I control for land suitability 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 determines on average 11.5% higher population density after the policy.[54]

In column 2, I flexibly control for suitability for agriculture. Interestingly,

[54] 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 first 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). Adding some assumption on the structure of the error term (see appendix F), the estimated parameter is approximately 63% (.1152/.1831).

the coefficient slightly increases in magnitude, suggesting that the absence of this control may imply a negative bias in the estimated coefficients.

Column 3 also controls for ruggedness, measured as standard deviation of elevation. In this case the estimated coefficient slightly decreases in magnitude, which is possibly due to the role of ruggedness in determining technological adoption in agriculture, in turn capturing useful variation in the index of the potential returns to the policy.

Column 4 flexibly controls for the historical presence of malaria. This control increases the coefficient of interest, suggesting that areas historically affected by malaria, which were also exposed to land reclamation, even being more exposed to the policy performed worse in terms of economic development, entailing negative bias in the estimated coefficient. The estimates imply that a one standard deviation increase in the exposure to the policy implies on average 10% larger population density after the introduction of the policy.

Table 4 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 by 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 above, it is plausible to consider that the policy stimulated a cumulative process of economic development that translated in different trends in the growth rates. This possibility is explored with a different empirical specification in the appendix tables A3 and A4.

Table 3: 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

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 4: 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

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 exposure to the BG on 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 relevance. In the following, I investigate this hypothesis examining the significance of placebo cutoff breaks before the policy. Table 5 illustrates the results.

In particular, columns 1 and 2 depict 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.[55] Column 3 uses as a placebo cutoff period year 1885, namely the post dummy takes value one over the year 1885 and until 1921, as indicated in column heading. Column 4 considers as a placebo year 1901. Column 5 and 6 use as a placebo cutoffs 1881 and 1871 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 in 1891 the population census was not taken.

This section illustrated that areas more exposed to the BG experienced a cumulative process of development that stimulated industrialization and population growth. Such effect emerged only after the introduction of the policy. In addition, it persisted after the repeal of the policy and until today. A closer look at the flexible estimates suggests that, while the effect on population density took place already during the period of the policy, the effect on

[55] The population censuses were not taken precisely every 10 years and the were not taken at all in some years (1891 and 1941), implying a frequency of the data that is not constant.

Table 5: 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.

manufacturing unfolded from 1951 onward, a period of significant economic growth. Taken together, the evidence indicates that areas who benefited from the policy acquired an advantage that unfolded during a subsequent period of industrialization to persist until contemporary period. In the following I advance a potential explanation to rationalize these findings.

6 Human Capital as a Channel of Persistence

The importance of human capital in agricultural production was studied dating back at least to Griliches (1963a,b, 1964). Moreover, the relevance of the complementarity between human capital and technical change was first underlined by Nelson and Phelps (1966).[56] In their influential study, they observe that farmers with higher levels of education have faster adoption of new agricultural innovations. This is because education increases farmers' ability to understand and evaluate new inputs and techniques. Thus, education

[56] On the relevance 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).

becomes more and more important in a fast changing environment in which there is a flow of new inputs and techniques. Therefore, substantial technical change increases the returns to human capital due to its relevance for 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 determined during the Indian Green Revolution increased the returns to education and stimulated human capital accumulation.[57] I conjugate this view in the context of the BG to explain its persistent positive effects.

In particular, the BG stimulated the creation of several new varieties of improved wheat seeds, new models of tractors, and new fertilizers. Ultimately determining a pervasive technical change in agriculture that involved several inputs. I hypothesize that the significant technological progress determined by the BG increased the returns to education and stimulated human capital accumulation, which was conducive for industrialization and economic growth. It is also possible that part of the ability to adopt new innovation would come from agriculture-specific education which, in fact, surged over the period of the BG (Hazan, 1933). However, general education would be still 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 the technology "appropriateness" by Basu and Weil (1998). Second, education enhances managerial ability. In particular, technical progress extends the set of production inputs[58] and increases managerial complexity, ultimately stimulating the returns to managerial human capital (Rosenzweig, 1980; Yang and An, 2002).

Given my hypothesis, I investigate whether the BG had positive effects on human capital accumulation in the form of education. I find evidence in support of this hypothesis using variation (i) across cohorts within munici-

[57] For other works that study the complementarity between agricultural technological progress and human capital see Welch (1970); Pudasaini (1983).

[58] On the increase in the set of inputs associated with technological progress, see Romer (1987, 1990).

palities; and (ii) across municipalities over time.

6.1 Cross-Cohorts Analysis

Given the hypothesis that the policy stimulated the incentives to accumulate human capital, such effect would be heterogeneous based on the age of people when the policy was operating. Namely, individuals who were already out of school were less likely to be affected by the policy in their education investment decision. Thus, the gap in educational attainment between cohorts that were in their 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 employed in manufacturing.

Cohort-level data on education and employment are available for 1971 and thus after the end of the policy. The data are aggregated in 6 groups of cohorts by municipalities. Table 6 illustrates the structure of the data cohort-groups. The first column shows the age range in the year of the census for each group, the second column shows the years range in which the cohorts were born in each group. The third column depicts the age range in the year in which the BG was implemented. The last column depicts the number assigned to each group. I order the groups from 1 to 6, where group 1 is the oldest.

Table 6: The Cohorts Structure in 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 cohort data are available aggregated in six groups. 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 in their school age when the policy was implemented, groups 1 and 2 were older and thus presumably less exposed to the policy. Groups 5 and 6 were yet to born in 1925. To investigate whether younger groups located in municipalities more intensely affected by the policy were characterized in 1971 by higher human capital, I estimate a model is very similar to the flexible-specification used in the previous section, with the key difference that I employ variation over groups of cohorts rather than time. The model is given by

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

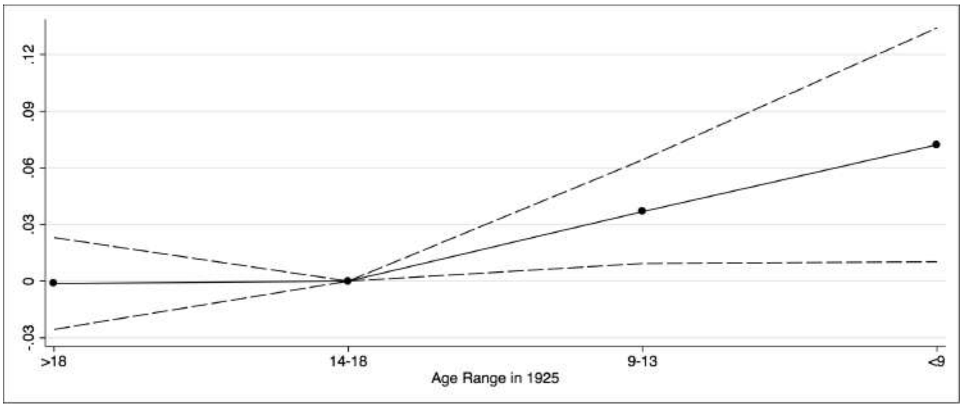
Where $Y_{i,g}$ is an outcome variable in municipality i, in cohort group g. For the human capital analysis, observations are by municipality, cohort-group and gender. α_i represents municipality fixed effects, α_{cg} is province by cohort-group fixed-effect. β_g is the set of flexible estimates obtained from interacting the growth in the PRI with cohort-groups dummies. As before, $\mathbf{X}$ represents flexible controls for land suitability for wheat and other geographic controls: ruggedness, land suitability for agriculture, and historical presence of malaria. For the analysis on human capital, I also control for gender by time fixed effects.

6.1.1 Human Capital across Cohorts

As a measure of human capital I employ the average years of education by cohort group and by gender. To calculate average years of education I consider only the adult population aged 25 or older (Barro and Lee, 1993), thus I exclude groups 5 and 6 (see table 6). The hypothesis is that groups 3 and 4 should be more educated than groups 1 and 2 in 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.[59]

The estimates of the flexible specification are depicted in figure 10 and illustrated in table A5. Coherently with the advanced hypothesis, in municipalities more exposed to the policy there was an increase in the average educational attainment precisely for those cohorts that were in their school age when the policy was implemented. In particular, the estimated coefficients become statistically significant for cohorts aged between 9 and 13 versus those aged between 14 and 18.[60]

Figure 10: The *Battle for Grain* and Human Capital across Cohorts: Flexible Estimates



Notes: The above figure depicts the coefficients 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 the 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 main text and appendices for variable definition and sources.

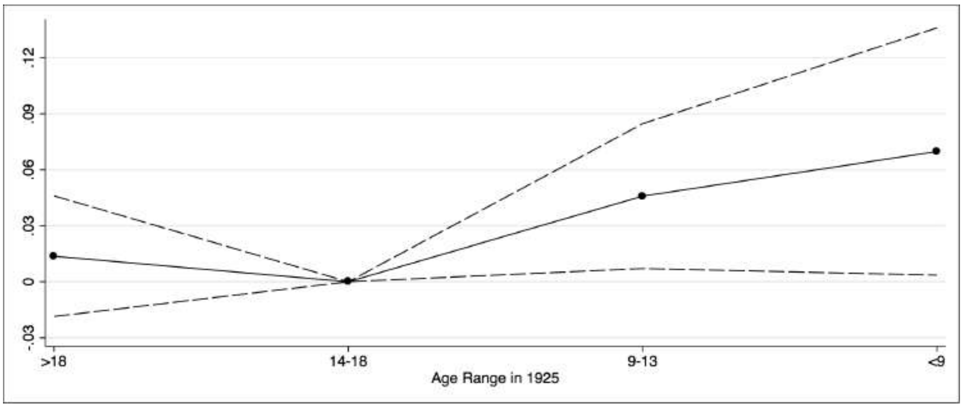
Foster and Rosenzweig (1996) have shown that, during the Indian Green Revolution, farmers invested more in the education of their male children as a response to the agricultural technical change. It is possible that a similar pattern may be present in the effect of the BG on education. To investigate this aspect, I perform the analysis for males. The estimated coefficients are depicted in figure 11. As evident from the figure, the increase in educational

[59] 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.

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

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 even in the case of the BG farmers initially invested more in the education of their sons.

Figure 11: The *Battle for Grain* and Human Capital across Cohorts: Flexible Estimates



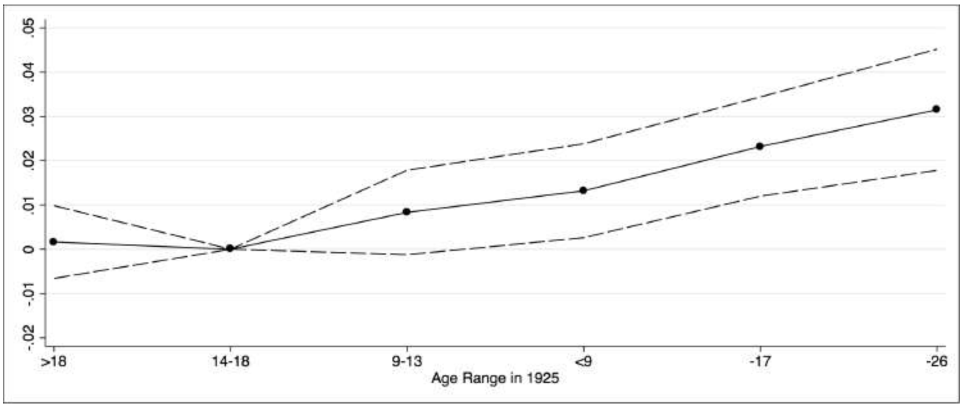
Notes: The above figure depict the coefficients estimates of (7) for the effect of growth in the Potential Revenue Index on the average years of education across cohorts for males, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression that 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 main text and appendices for variable definition and sources.

In the following I turn to examine whether the analysis across cohorts confirm the results shown above on the effect of the policy on industrialization.

6.1.2 The Transition to Industry across Cohorts

Figure 12 illustrates the flexible estimates using as an outcome variable the share of labor in manufacturing. Given that the outcome variable is the employment share of manufacturing conditioning on working, I can extend the analysis to younger cohorts as of 1971. Reassuringly, the results across cohorts confirm those across municipalities over time. Namely, younger cohorts that were more exposed to the policy as they had yet to reach working age experienced a faster transition to the manufacturing sector. The effect emerged precisely over the groups of cohorts that reached their 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 12: The *Battle for Grain* and Industrilization across Cohorts: Flexible Estimates



Notes: The above figure depict the coefficients 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 the 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 main text and appendices for variable definition and sources.

Table 7 depicts the cross-cohorts estimates from regressing the education and employment shares on my measure of exposure to the policy interacted with an indicator that takes value one if the cohort is school-aged (i.e. younger than 14) when the policy was implemented. Column 1 depicts the result using as an outcome the average years of education. Column 2 illustrates the estimated coefficient on my measure of industrialization across cohorts. Consistently 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 share of labor in agriculture. The negative coefficient in column 3 is consistent with the hypothesized effect of the BG on accelerating the transition out of agricultural activities toward manufacturing. Finally, column 4 uses as an outcome variable the employment share in all the other

Table 7: The *Battle for Grain*, Education, and Industrialization Across Cohorts

	Dependent Variable:			
	(1) Avg. Years Education	(2) Empl. Share in Manufacturing	(3) Empl. Share in Agriculture	(4) 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 depicts 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, transports, 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). 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.

sectors with the exclusion of agriculture and manufacturing.[61] The estimated coefficient is not statistically different from zero. Taken together, this table suggests that the policy stimulated human capital accumulation as well as an exodus from agriculture toward the manufacturing sector that was still present across cohorts within municipalities in 1971. In addition, the absence of a persistent effect of the policy on the service sector across cohorts can be interpreted as evidence that, at the local level at which the analysis is performed, the effect of the policy did not necessarily unfold through the expansion of the non-tradable goods sectors.[62]

In this section I have shown that cohorts in their school age at the time of the policy experienced faster increase in educational attainment in municipalities more exposed to the BG. Furthermore, consistently with the literature on the green revolution, the effect is stronger for males. In addition, the cross cohorts estimates confirm the results shown in the previous sections on the effect of the policy on the transition to industry.

In the empirical strategy adopted in this section, the identification assumption relies on the absence of a third factor that is correlated with the potential exposure to the BG and that fostered educational attainment precisely for those cohorts that were in their school age at the time of the BG. Nevertheless, given that I only observe cohorts in 1971 and thus after the BG, migration patterns across municipalities may affect the estimates. While it seems unlikely that school age children prone to invest in education migrated during the BG toward areas more exposed to the policy, it is possible that those cohorts migrated in later stages and, in particular, between the 1950's and 1970's. To minimize this concern, in the next section I employ educational attainment data across municipalities for an earlier period closer to the end of the BG.

Finally, given that all cohorts were, to some extend, exposed to the BG

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

[62] Interestingly, Bustos et al. (2016) have similar findings for contemporary Brazil.

it is difficult to get a sense of the magnitudes of the effect of the BG on education. For this additional reason, in the next section I employ variation in educational attainment across municipalities over time.

6.2 Human Capital across Municipalities

In this section, I study the effect of the BG on human capital across municipalities over time. To measure education I use two variables. First, I employ the share of people aged 14 or older with at least a middle school degree in 1951.[63] Second, I employ average years of education in 1951 and 1971, converted from education attainment levels using duration of each level.[64] Given that I want to capture the effect of the policy on the change in education, I have to control for education before the policy. Unfortunately, for the period before the policy, only data on literacy rates are available. Thus to take into account preexisting differences in education, I control for literacy rate in 1921[65] However, given that literacy may be an imperfect control for education, I control for a large set of geographic and socioeconomic characteristics, and for province fixed effects.

The estimated model is given by

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

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.

[63] I use middle school degree because elementary school was compulsory. Thus cross sectional differences in elementary school graduates would be heavily driven by older people who were unlikely to be affected by the policy in their educational choice. In addition, on average only 2.5% of the population had a degree higher than the middle school.

[64] See appendix for variable construction and sources.

[65] Controlling also for non linear effects of literacy has no effect on the estimated coefficients.

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,[66] 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). Finally, 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. I also control for the standard measure of market access by Harris (1954), measured by the log of the average population in neighbor municipalities weighted by distance. Finally, to further control for preexisting economic development, I control for the density of ancient roman roads.

Table 8 shows that the growth in the PRI has a positive and significant effect on education. Consistently with the advanced hypothesis, 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 degrees. Column 2 shows that the coefficient of interest increases in magnitude after controlling for literacy before the policy. Suggesting 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

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

account. Interestingly, the magnitude of the estimated coefficients is smaller in column 6 with respect to column 4. Suggesting 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 in the previous section. Finally, column 7 performs a placebo check where I use 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 noticing 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 effects on human capital unfolded through technological improvements. In the following, I will further investigate this hypothesis.

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 9, I investigate this possibility also across municipalities. The estimates are very similar to the ones illustrated in table 8. However, consistently with the cross-cohorts case, the estimated effect is larger for males.

6.2.1 Technology versus Price Effect

The BG combined agricultural technical change with protection. This section investigates these two effects to understand whether the estimated positive effect of the BG on education is driven by agricultural technical change or by the higher returns to factors in agriculture associated with the wheat price shock. To do so, I split my measure of the potential returns from the policy in its part due to technical change and the other part due to the increase in the relative wheat price. Results are illustrated in table 10.

As evident from the table, areas more exposed to the technological progress determined by the BG experienced an increase in education that persisted until 1951 and 1971. This result confirms the hypothesis that the

Table 8: 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 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.

Table 9: The *Battle for Grain* and Males' Human Capital 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 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.

Table 10: 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.

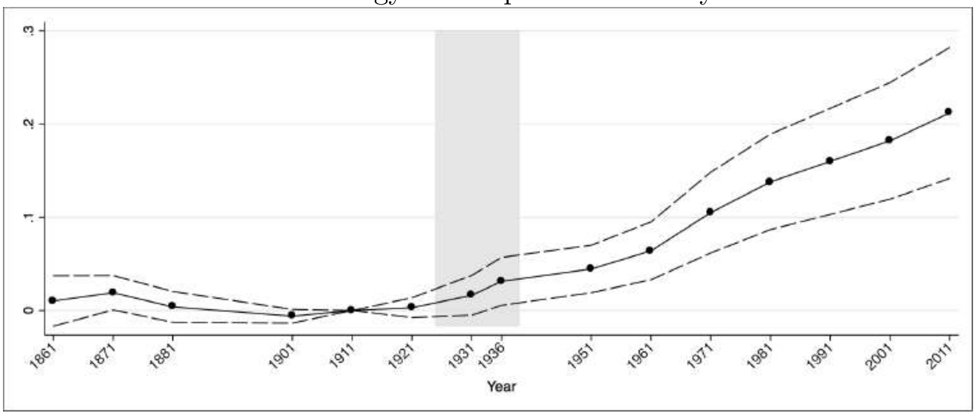
positive effect of the BG on human capital accumulation functioned through technical change, rather than an increase in wheat prices. In fact, areas that benefited from the policy through the increase in the relative price of wheat, conditioning on technological progress, did not experience a significant increase in education. If anything, the sign of the coefficient is negative, albeit statistically insignificant. This result further emphasizes the skilled-bias nature of the technical change determined by the BG.

Once established the relevance of technical change in explaining the effect of the BG on human capital, I investigate the relevance of technical change on development and industrialization. I employ the flexible specification illustrated in section 5.2.2. Figures 13 and 14 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 confirm the finding for human capital. Interestingly, as depicted in the bottom panel of figure 14, the short run effect of the price shock on industrial development is negative and significant. Then, it dissipates over time. This finding suggests that the a rise in the returns to factors in agriculture, as determined by tariffs, may crowd-out the manufacturing sector only in the short run. Which is consistent with the findings related to the Green Revolution in India (Foster and Rosenzweig, 2004) and suggests that, while transitory protection can spur technological progress and long-term development, its negative effects on non-protected sectors may not be long-lasting.

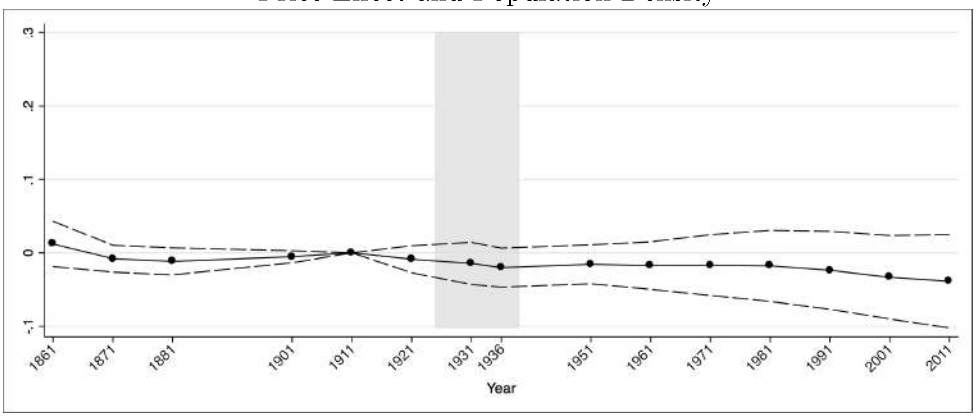
Taken together, the results of this section show that the positive shock to technological progress in agriculture determined by the BG was skilled-bias, in turn stimulating human capital accumulation. Instead, the increase in wheat price, and the associated symmetric increase in the returns to factors employed in agriculture, had limited effects on human capital accumulation. This result 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 determine specialization in this sector, ultimately hampering human capital accumulation (Galor and Mountford,

Figure 13: Technology versus Price effect and Population Density

Technology and Population Density

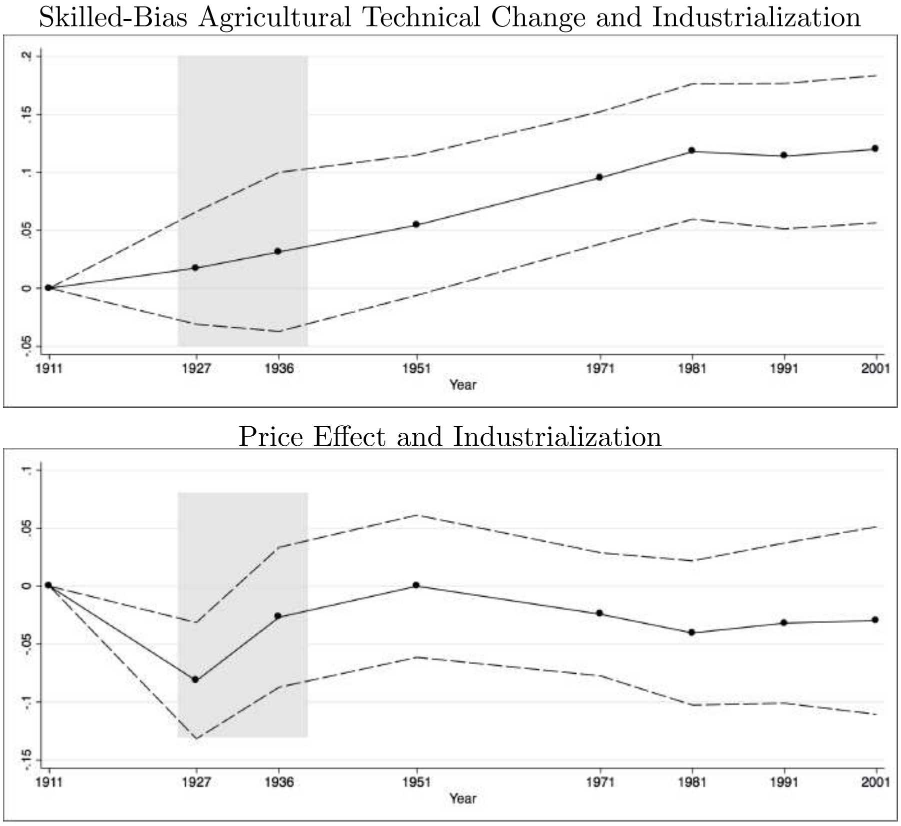


Price Effect and Population Density



Notes: The above figures depict the coefficients estimates of (5) for the effect of growth in the Potential Revenue Index due to technical change (top panel) and price change on population density measured in natural logarithms. Estimates are from the a regression that includes both indexes, municipality fixed effects, province specific time fixed effects, and flexibly controls for latitude, terrain ruggedness, and historical presence of malaria. See main text and appendices for variable definition and sources.

Figure 14: Technology versus Price effect and Industrialization



Notes: The above figures depict the coefficients estimates of (5) for the effect of growth in the Potential Revenue Index due to technical change (top panel) and price change on the share of people in manufacturing. Estimates are from the a regression that includes both indexes, municipality fixed effects, province specific time fixed effects, and flexibly controls for latitude, terrain ruggedness, and historical presence of malaria. See main text and appendices for variable definition and sources.

2008) and the transition to industry (Matsuyama, 1992; Bustos et al., 2016).

Furthermore, this result sheds light on the effects of transitory protectionist policies. While the technological progress determined by the BG stimulated human capital and economic development, the effect of tariffs alone, conditioning on potential technological improvements, had limited, or even negative, effects.

Finally, it is worth noticing that the decomposition performed in this section cannot uncover what would have been the effect of the stimulus to technological progress in the absence of protection (or *vice versa* the effect of tariffs without the stimulus to technological progress). In fact, it is possible that there would have been little technological progress in the absence of protection. However, the analysis can shed light on the effect of the stimulus to technological progress *conditioning* on protection (and *vice versa* the effect of tariffs conditioning on technological progress), ultimately shedding light on the mechanisms through which the policy operated.

7 Conclusions

This study explores the *Battle for Grain*, an agricultural policy undertaken by the Italian fascist regime to achieve self-sufficiency in wheat production, to shed light on the long-run consequences of a rise in agricultural productivity on the transition to industry and economic development. The policy determined a comprehensive stimulus to modern wheat production technologies and, to foster technology adoption, temporary protection in wheat. The heterogeneous effects of the policy across areas with different geographic conditions allow me to study these two aspects separately.

I find that the technological progress determined by the BG was conducive for human capital accumulation, industrialization and long-term development. However, the effect of the higher wheat prices had limited effects on human capital accumulation and economic prosperity.

The different effects of technical change and the price shock induced by protection highlight that, while a factor-neutral increase in agricultural productivity may have limited effects on human capital and industrial development, rising agricultural productivity due to a comprehensive stimulus to multiple agricultural inputs can increase the returns to human capital investment which, being conducive for industrialization, fosters economic development in the long run.

In addition, the paper sheds light on the debate on the effect of transitory protectionist policies on economic development in the long run. In particular, the evidence highlights that transitory protectionist policies that enhance productivity and technological progress may foster human capital accumulation and economic development.

Finally, the findings suggest that temporary policies that embed important stimulus to technological progress can trigger human capital accumulation and have significant positive effects on long-term economic prosperity, ultimately deepening our understanding of the development process and policy design.

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Appendices

A Complementary Tables

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

	(1) Ln Population Density	(2) Manufacturing Pop. Share
$\Delta y^{w}_{23-29}\times 1861$	-0.0028	
	[0.010]	
$\Delta y^{w}_{23-29}\times 1871$	-0.0011	
	[0.006]	
$\Delta y^{w}_{23-29}\times 1881$	-0.0113**	
	[0.005]	
$\Delta y^{w}_{23-29}\times 1901$	-0.0017	
	[0.003]	
$\Delta y^{w}_{23-29}\times 1911$	0	0
$\Delta y^{w}_{23-29}\times 1921$	0.0032	
	[0.003]	
$\Delta y^{w}_{23-29}\times 1927$		0.0108
		[0.017]
$\Delta y^{w}_{23-29}\times 1931$	0.0022	
	[0.006]	
$\Delta y^{w}_{23-29}\times 1936$	0.0125*	0.0076
	[0.007]	[0.019]
$\Delta y^{w}_{23-29}\times 1951$	0.0258***	0.0393*
	[0.008]	[0.023]
$\Delta y^{w}_{23-29}\times 1961$	0.0417***	
	[0.011]	
$\Delta y^{w}_{23-29}\times 1971$	0.0671***	0.0515*
	[0.016]	[0.027]
$\Delta y^{w}_{23-29}\times 1981$	0.0877***	0.0773***
	[0.021]	[0.028]
$\Delta y^{w}_{23-29}\times 1991$	0.1053***	0.0870***
	[0.024]	[0.029]
$\Delta y^{w}_{23-29}\times 2001$	0.1169***	0.0846***
	[0.027]	[0.030]
$\Delta y^{w}_{23-29}\times 2011$	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 *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-cohort-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 6 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 Spatial Analysis

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 B1 depicts 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 32). Interestingly, the coefficient 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.

In showing that the variation is local, one concern may arise. In particular, it is possible that neighbor municipalities may have an independent effect on economic development and be correlated with the technical change in agriculture associated with the BG. In order to examine this aspect, column 7 controls for the average growth in the PRI for all the neighbor municipalities weighted by distance. Controlling for this variable has little impact on the estimated coefficient of interest.

B.2 Heterogeneous Effects

The evidence shown highlights the importance of agricultural technical change in stimulating the transition to industry and long-term development.

Table B1: Baseline Estimates: Spatial Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable: *Ln Population Density*							
		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 depicts 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 neighbor 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.

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 B2.

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.[67]. 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.[68] 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

[67] See, e.g., Zamagni (1993), Daniele and Malanima (2011), Felice (2013).
[68] I follow the official definition from ISTAT.

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, in turn mitigating this concern.

In section B.1, 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 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.[69] The estimated coefficients are negative and statistically insignificant. Suggesting

[69] 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.

that the estimated effect is driven by smaller municipalities that are less urbanized and thus more likely to be exposed to agricultural policies.

Table B2: 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.3 Other Policies

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 B3.

An important policy undertaken over this period of time was land reclamation of areas historically affected by malaria. Columns 1 and 2 examines the interaction between the BG and this intervention. Column 1 depicts the interaction with an indicator that takes value one if the municipality

Table B3: Other Policies

	Dependent Variable: Ln Population Density					
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Malaria 1870	New Cities	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.

was historically affected by malaria (see 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 cities to populate the newly available land. Column 2 depicts 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.[70]

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.[71] 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.[72]

B.4 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 B4.

[70] The reduction in the coefficient of interest in column 3 may be explained by the positive correlation between railroads in 1931 and railroads presence after the BG, which are an indicator of development after the policy.

[71] Others have emphasized that farm size is an important determinant of differences in agricultural productivity, for instance see Foster and Rosenzweig (2011); Adamopoulos and Restuccia (2014).

[72] 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.

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 industries that are more skilled-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 B4: 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.5 Additional Robustness and Placebo Checks

B.5.1 Robustness to Placebo Versions of the Potential Revenues Index with Major Crops

Table B5: 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.5.2 Robustness to Alternative Versions of the Potential Revenues Index

Table B6: 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 depicts 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 depicts 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 B7: 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 depicts 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 depicts 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 B8: 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 depicts 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 depicts 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 B9: 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 depicts 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 depicts 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.5.3 Robustness to Placebo Policy Timings with Alternative Specification

Table B10: 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.5.4 Robustness to Weighted Regression in the Cross-Cohorts Analysis

Table B11: 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-cohort-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 6 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.

Table B12: The *Battle for Grain* 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-cohort. 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 depicts 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, transports, 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.

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 15 and 16 show maps of suitability for wheat and contemporary economic development across European provinces.[73] 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 depicts 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.[74] 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.[75] For what concerns the United Kingdom and Spain, the estimates are statistically insignificant.

---

[73] Economic development is measured by income per capita in 2011. See appendix E for variable sources.

[74] Regional fixed effects are at the NUTS 2 level.

[75] Throughout the period of the BG, Italy and France were the biggest consumers of wheat (Cohen, 1979)

Figure 15: Land Suitability for Wheat acrosss European Provinces

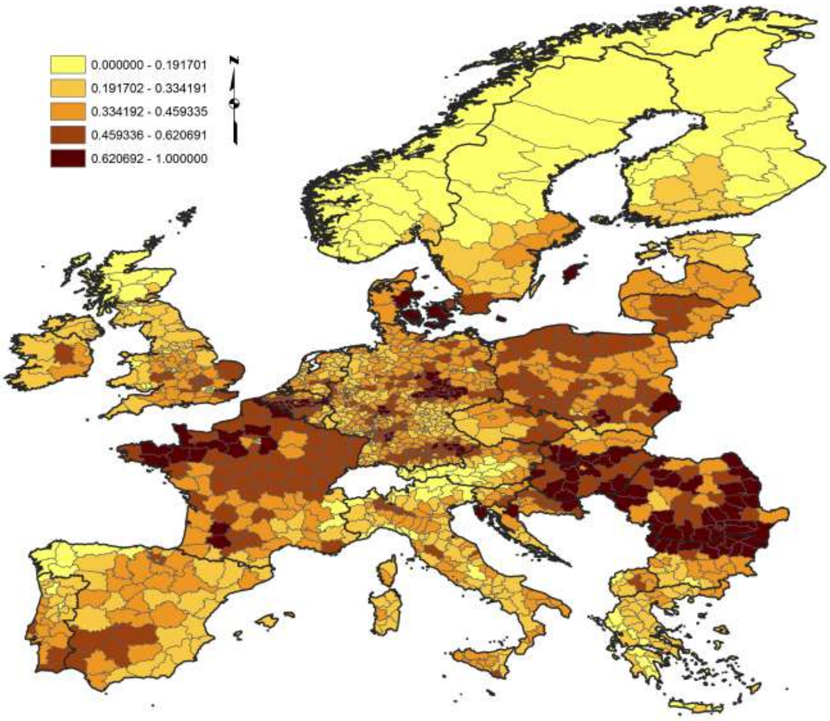


Figure 16: GDP per capita in 2011 (logs).

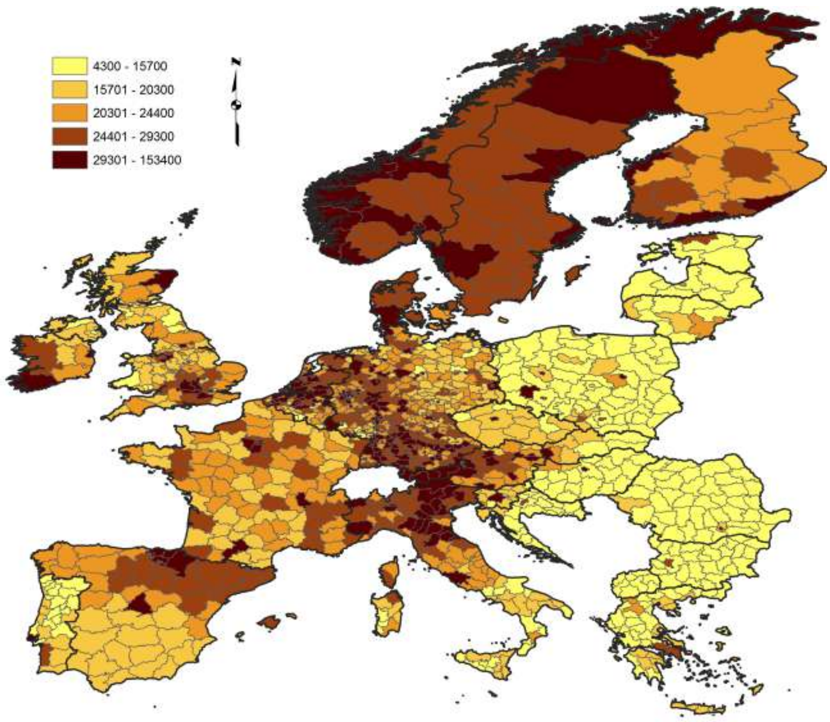


Table C1: Land Suitability for Wheat and Development in Europe. OLS

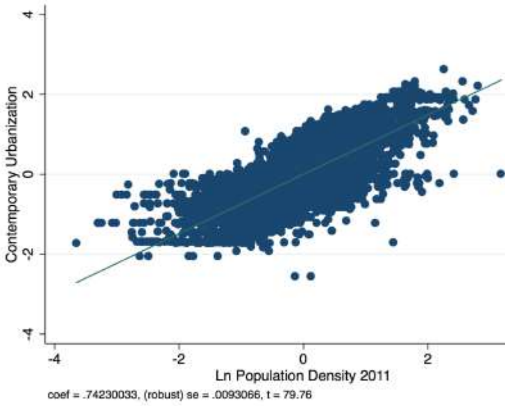
Dependent Variable: *Ln Contemporary Income*						
	(1) Italy	(2) Europe (No Italy)	(3) France	(4) Germany	(5) UK	(6) Spain
Wheat Suitability	0.2928**	-0.4945***	-0.9187**	-0.6288***	-0.0754	0.0512
	[0.122]	[0.104]	[0.412]	[0.156]	[0.303]	[0.213]
Std. β	0.124	-0.178	-0.633	-0.228	-0.0334	0.0269
Observations	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.

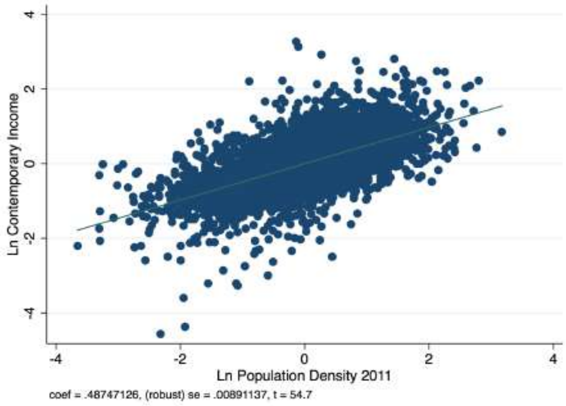
The evidence reported in this section supports the hypothesis that geographic conditions that make areas more suitable to produce wheat are not necessarily conducive for economic development. Given that wheat suitable places were more exposed to the BG, this finding minimizes concerns on the potentially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

D Figures

Figure 17: Population Density and Economic Development



(a) Urbanization



(b) Income

Notes: The figures reports estimates that underline the validity of population density as a measure of economic development across Italian municipalities in contemporary periods. Panel 17a 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 17b 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 18: GDP per capita Italy 1700 - 2000 (1817=1). Source: (Malanima, 2007).

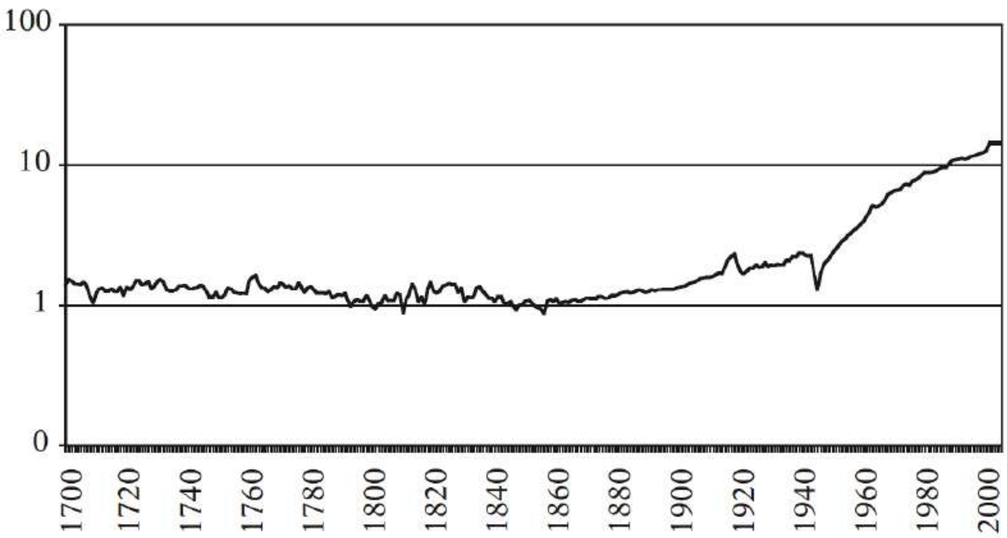
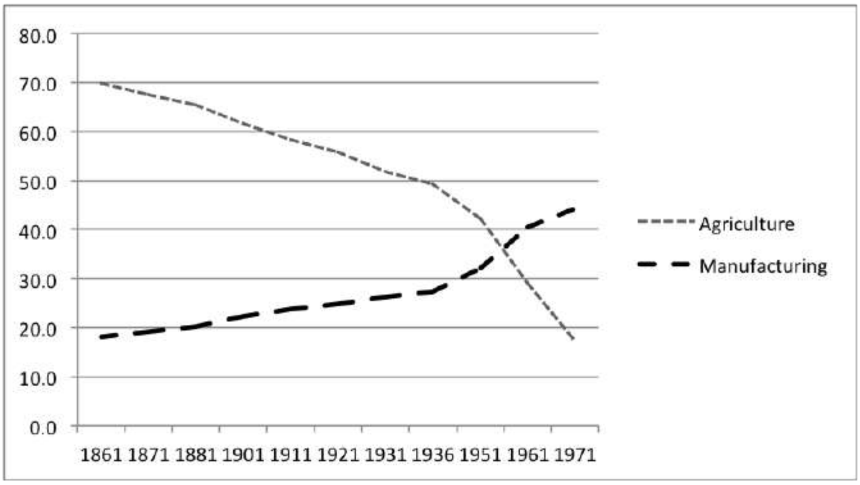
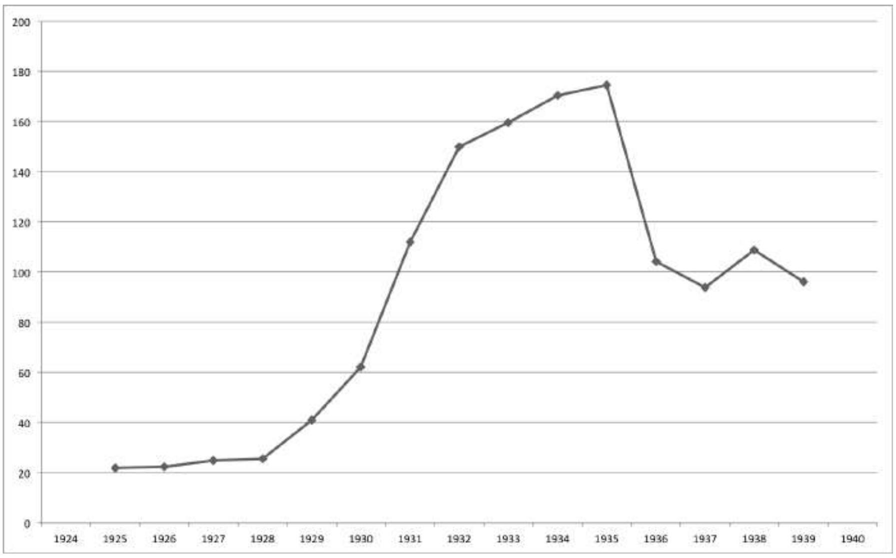


Figure 19: Emplyoment Shares in Agriculture and Manufacturing



Notes: The 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 20: Wheat Tariff Rate.



Notes: The figure depicts the import tariff applied to soft wheat relative to its international price (Source: Baldini 1963; Mortara 1933). Notice that over the 1930's the tariff rate reached more than 100% of international wheat price. Yearly data on wheat tariff are only available for soft wheat. However, similar tariffs were applied to hard wheat as also shown by the fact that domestic prices of hard and soft wheat correlates almost perfectly (see figure 29).

Figure 21: Price of Wheat and Selected Crops

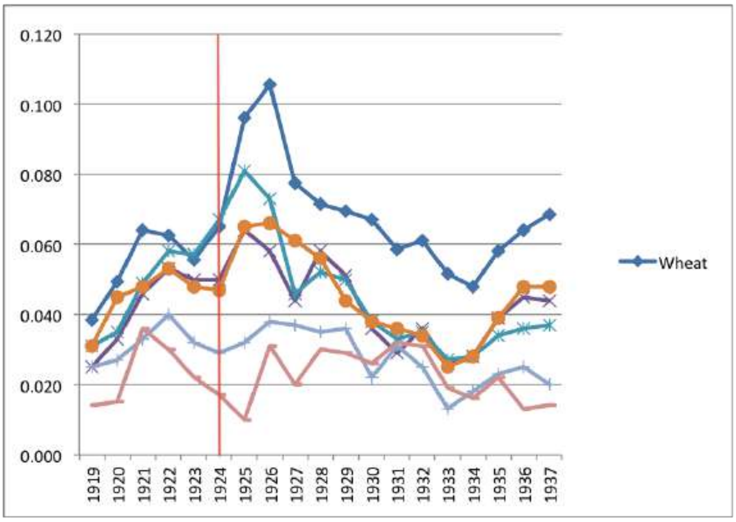


Figure 22: Real Price of Wheat and Selected Crops

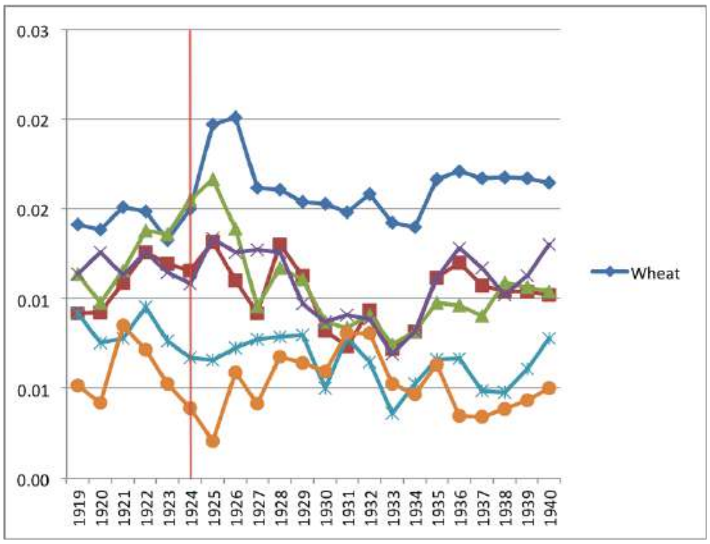
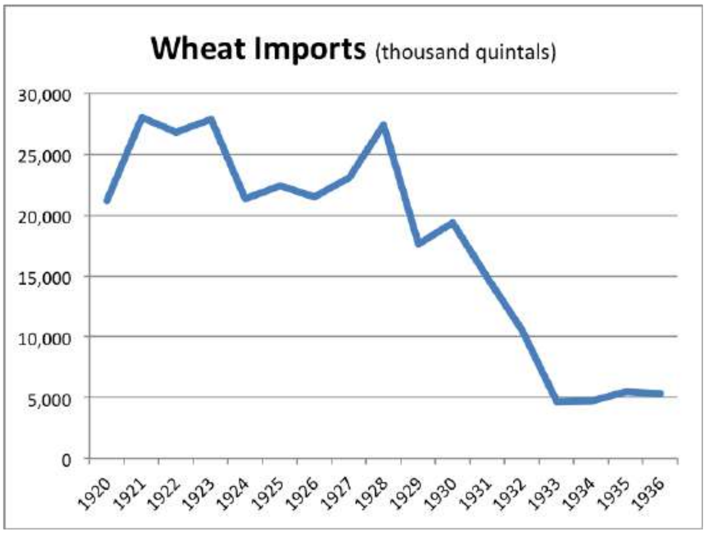
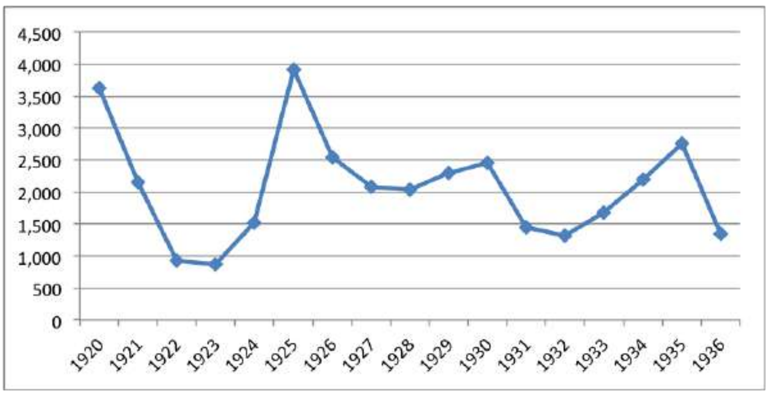


Figure 23: Wheat Imports



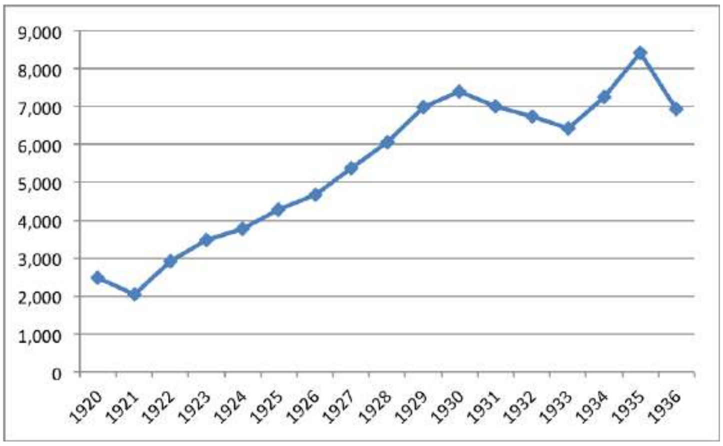
Notes: The figure shows wheat imports over the period of the policy (thousand of quintals. source: ISTAT). Note that between 1928 and 1929 there was a significant reduction in the price of wheat from the United States, which was one of the main exporters of wheat. As a result, the negative trend in wheat imports shown in the panels above is characterized by a temporary positive peak. The reaction of the government was an immediate and substantial increases in the tariff (Lorenzetti, 2000, p. 262), which is also evident in figure 20.

Figure 24: Imports of Steel and Iron Products



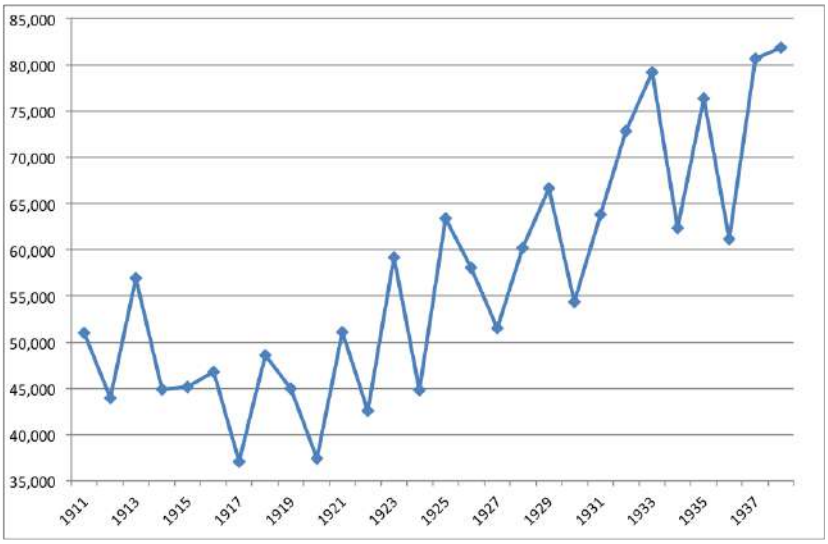
Notes: The figure shows imports of steel and iron products over the period of the policy (thousand of quintals. source: ISTAT).
Notes: The figure shows that imports (in thousand of quintals) of steel and iron products does not exhibits the downward pattern displayed by wheat imports over the period of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

Figure 25: Imports of Oil and Derivatives



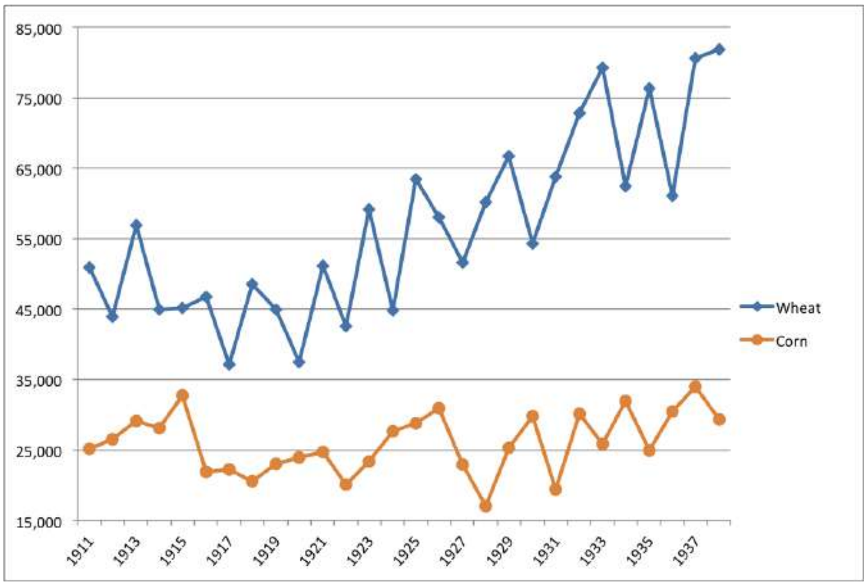
Notes: The figure shows that imports (in thousand of quintals) of raw mineral oils and derivatives does not exhibits the downward pattern displayed by wheat imports over the period of the *Battle for Grain*. Source: ISTAT.

Figure 26: Domestic Wheat Production



Notes: The figure shows domestic wheat production over the period of the policy (thousand of quintals. source: ISTAT).

Figure 27: Domestic Wheat and Corn Production



Notes: The figure shows domestic wheat and corn production over the period of the policy (thousand of quintals. source: ISTAT). While wheat production increased over the period of the *Battle for Grain*, corn production remained at pre-policy levels.

Figure 28: Map of coverage and list of the 94 volumes that compose the Census of Agriculture 1929.

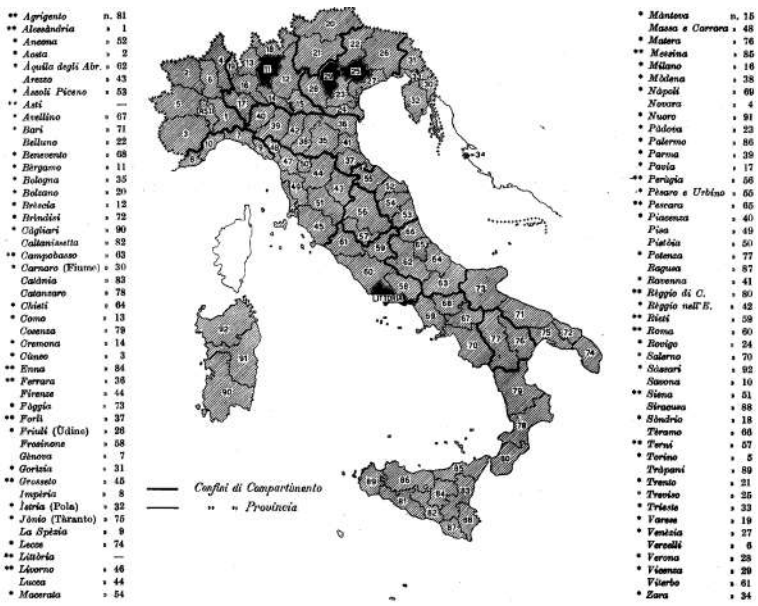


Figure 29: Domestic price of soft and hard wheat. Source: ISTAT.

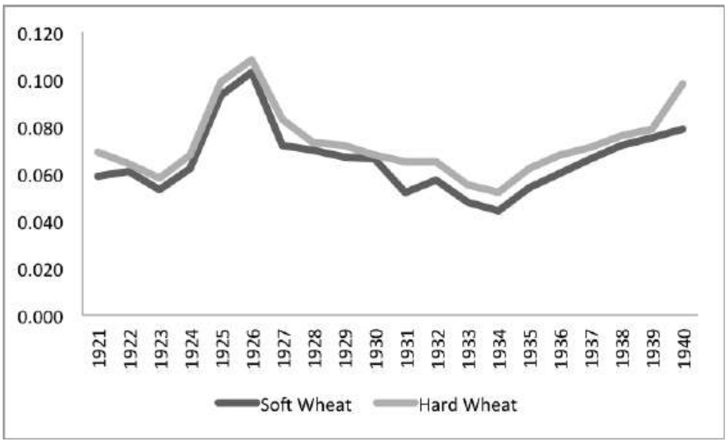


Figure 30: The Increase in Wheat Yield 1923-1929

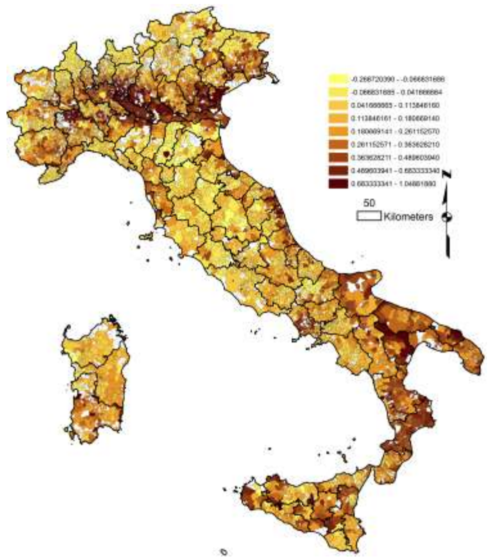


Figure 31: The Potential Returns from the *Battle for Grain*

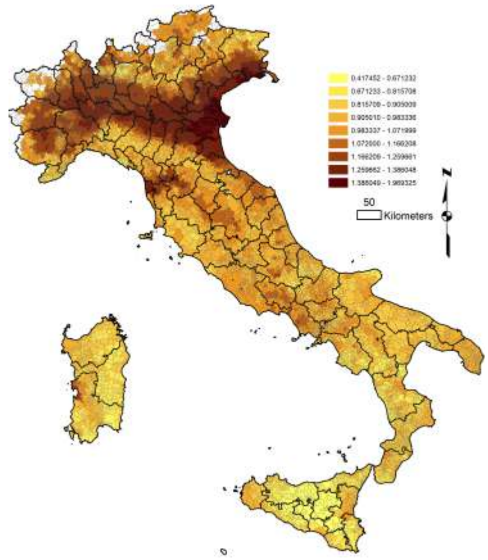
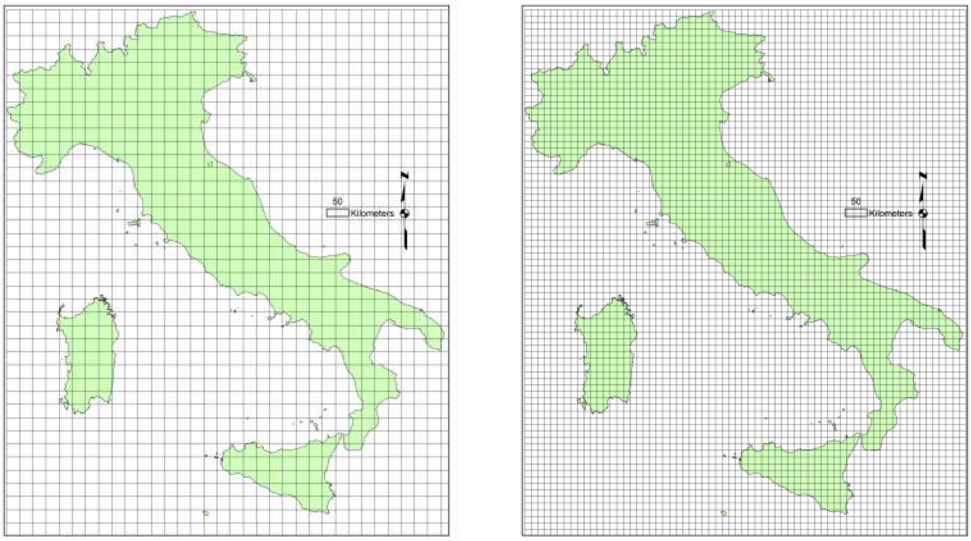


Figure 32: Grid Size Examples: Spatial Analysis

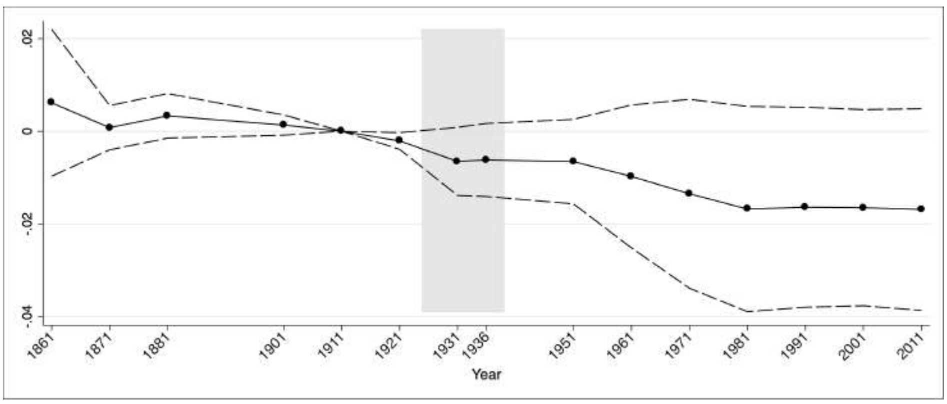


(a) 30 km^2 Grid

(b) 15 km^2 Grid

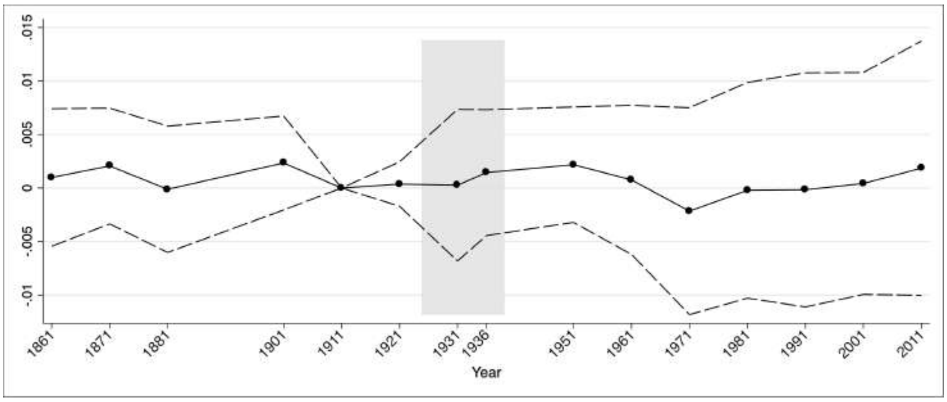
Notes: The above panels show the size of the grid used in the spatial analysis for 30 and 15 km^2 respectively.

Figure 33: Placebo Estimates: Change in Potato Yield and Population Density



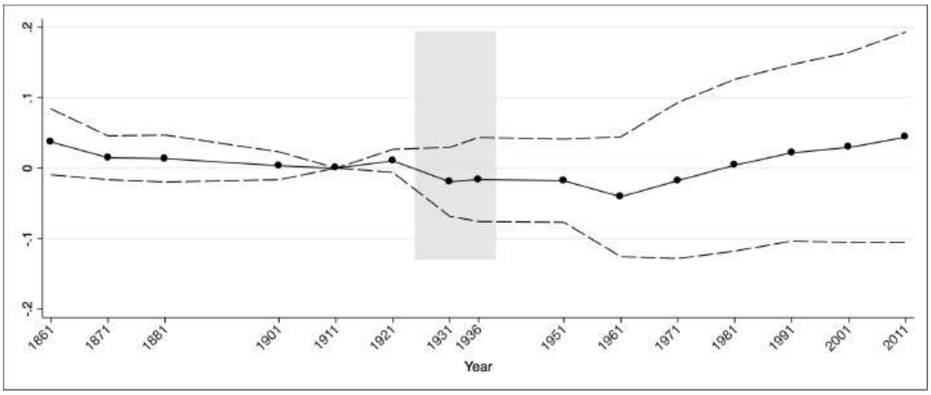
Notes: The above figure depicts the coefficients estimates of (1) from regressing population density measured in natural logarithms on the change in potato yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression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

Figure 34: Placebo Estimates: Change in Rice Yield and Population Density



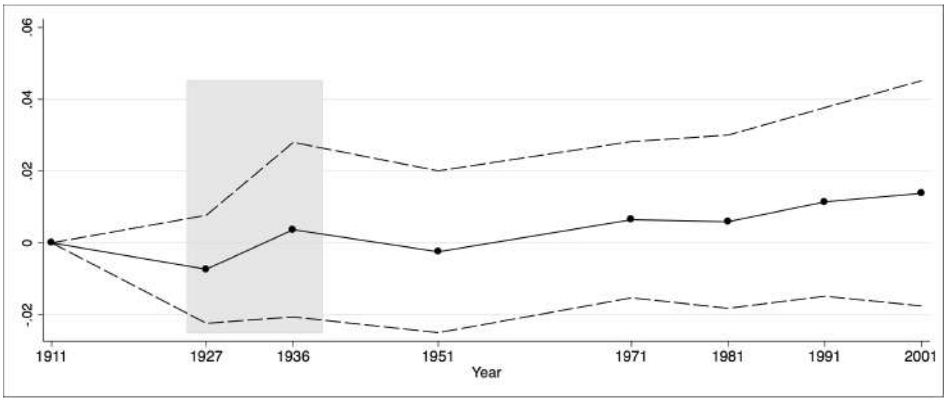
Notes: The above figure depicts the coefficients estimates of (1) from regressing population density measured in natural logarithms on the change in rice yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression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

Figure 35: Placebo Estimates: Change in Corn Yield and Population Density



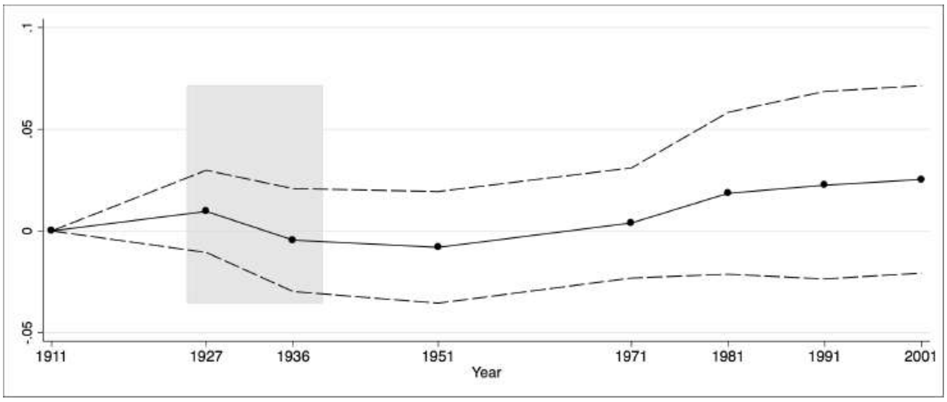
Notes: The above figure depicts the coefficients estimates of (1) from regressing population density measured in natural logarithms on the change in corn yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression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

Figure 36: Placebo Estimates: Change in Potato Yield and Industrialization



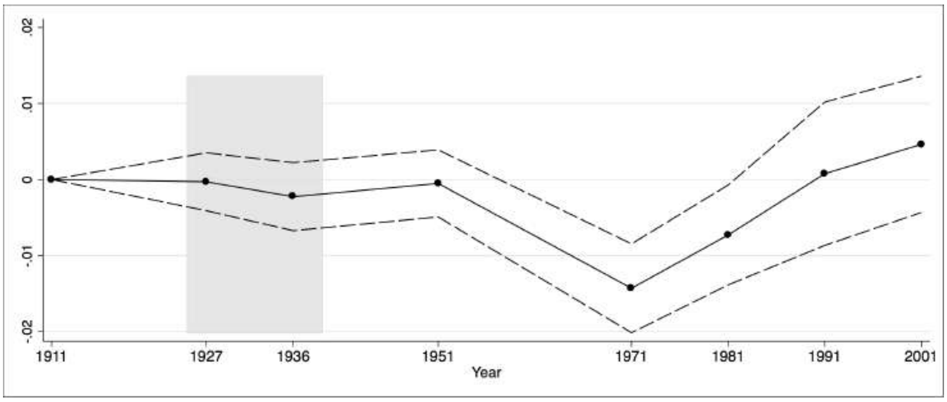
Notes: The above figure depicts the coefficients estimates of (1) from regressing the share of population in manufacturing on the change in potato yields over the years 1923-1929, and 95% confidence intervals based on province-level clustered standard errors. Estimates are from the a regression that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

Figure 37: Placebo Estimates: Change in Rice Yield and Industrialization



Notes: The above figure depicts the coefficients 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 the a regression that include municipality fixed effects and province specific time fixed effects. See main text and appendices for variable definition and sources.

Figure 38: Placebo Estimates: Change in Corn Yield and Industrialization



Notes: The above figure depicts the coefficients 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 the a regression that include municipality fixed effects and province specific time fixed effects. See main text and appendices for variable definition and sources.

E Variables description and sources

Suitability for agriculture. The variable is based on the Caloric Suitability Index (Galor and Özak (2014), 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. Data for the historical presence of malaria are from Torelli (1882). I have digitized this map of malaria prevalence in Italy in 1870. Then I have created an indicator variable that equals one if a given municipality was characterized by the presence of malaria in 1870. In particular, the variable takes value one if the centroid of the municipality is less than 5 kilometers away from malarial zones.

Elevation variables. Median and standard deviation of elevation are calculated with GIS software using the GOTOPO 30 - 30 arc seconds resolu-

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

tion 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.

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. The Census of Population for the years 1891 and 1941 were not taken. 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 cohorts, I assign zero years of education to people without a degree. For the average years of education across municipalities, I cannot consider individuals without a degree because I do not know 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.

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.

E.1 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.2 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 En-*

trate (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.3 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.[76]

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

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).

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

$$Y_i = \beta \Delta y^* + \epsilon_i \tag{9}$$

where Y_i represents an outcome variable for municipality i. $\Delta y^* \equiv (y_{29} - y_{25})$ 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.[77]

What is instead observed is $\Delta y \equiv (y_{29} - \bar{y}_{23-28})$, where $\bar{y}_{23-28}$ 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

$$Y_i = \hat{\beta} \Delta y + \eta_i \tag{10}$$

where it is assumed that

$$E[\eta_{it} \; \epsilon_{it}] = 0 \tag{11}$$

Note that Δy can be written as the difference of the unobserved policy driven

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

productivity change and a measurement error term. Namely,

$$\begin{aligned}
\Delta y &\equiv (y_{29} - \bar{y}_{23-28}) & (12)\\
&= (y_{29} - y_{25}) - (\bar{y}_{23-28} - y_{25}) & (13)\\
&\equiv \Delta y^{*} - \Delta y^{0} & (14)
\end{aligned}$$

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

$$\begin{aligned}
Var[\Delta y^{*}] &\equiv \sigma & (15)\\
Var[\Delta y^{0}] &\equiv \sigma_0 & (16)\\
Cov[\Delta y^{*}, \Delta y^{0}] &\equiv \lambda & (17)
\end{aligned}$$

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

$$\hat{\beta} = \frac{Cov[\Delta y^{*} - \Delta y_0, \beta \Delta y + \epsilon_{it}]}{Var[\Delta y^{*} - \Delta y^{0}]} \tag{18}$$

therefore

$$\begin{aligned}
plim\hat{\beta} &= \beta\Big[\frac{\sigma - \lambda}{\sigma + \sigma_0 - 2\lambda}\Big] & (19)\\
&= \beta\Big[1 - \frac{\sigma_0 - \lambda}{\sigma + \sigma_0 - 2\lambda}\Big] & (20)
\end{aligned}$$

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, Δy^{*}, and its measurement error, Δy_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 Δy 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

$$\Delta y^{*} = \phi \Delta lnPRI + \eta_i$$

Given (14), I can write

$$\Delta y^{w} = \phi \Delta lnPRI + \eta_i - \Delta y_0 \tag{21}$$

The OLS estimate of ϕ is given by

$$\hat{\phi} = \frac{Cov[\Delta y, \Delta lnPRI]}{Var[\Delta lnPRI]} = \frac{Cov[\phi \Delta lnPRI + \eta_i - \Delta y_0, \Delta lnPRI]}{Var[\Delta lnPRI]} \tag{22}$$

therefore

$$plim\hat{\phi} = \phi - \frac{Cov[\Delta lnPRI, \Delta \tilde{y}_0^{w}]}{Var[\Delta lnPRI]} \tag{23}$$

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

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

Given the above assumptions, I can write

$$\Delta\tilde{y}_0^w = \frac{1}{4}\Delta y_0^w$$

which, substituted in (23), implies that

$$plim\hat{\phi} = \frac{3}{4}\phi \tag{24}$$

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.