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Would a central planner let people starve? The great unsolved puzzle of china's great famine (1958-61)

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Abstract

China's Great Famine killed up to 45 million people. Recent research shows that Chinese leader Mao Zedong is aware that people are starving, but instead of providing famine relief (e.g. grain imports) he orders policies that exacerbate the famine (e.g. grain exports). I ask if Mao has incentives to let people starve: Does famine mortality contribute to his goal of transforming China into an industrial power? Theoretically, I show that famine mortality can increase industrial output in a centrally planned two-sector economy (agriculture and industry) with surplus labor (the marginal product of agricultural labor is zero) and where agricultural savings (e.g. grain exports) are the source of industrial capital (e.g. imports industrial equipment). Intuitively, the annihilation of surplus labor, e.g. through famine, increases agricultural savings by reducing the wage bill without affecting agricultural output. The planner invests these additional savings in the industrial sector (e.g., imports of industrial equipment financed through grain exports). The less-populous economy has thus more industrial capital but fewer industrial labor, and industrial output is higher if the positive effect of the former exceeds the negative effect of the latter. This is plausibly the case when industrialization is in its infancy (the marginal product of industrial capital is high). Novel econometric analysis suggests that the model provides a realistic description of Mao's economy.

I have profited from comments provided by two anonymous referees.
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"I did not immediately understand, because it was so hard to accept, how willing Mao was to sacrifice his own citizens in order to achieve his goals (...) Mao knew that people were dying [starving] by the millions. He did not care."
Dr. Li (1994, p. 300), Mao Zedong's personal physician and confidant.

1. Introduction

China's Great Famine (1959-1961) killed up to 45 million people. Recent empirical research identifies the government's excessive procurement and exports of grain as one of the chief causes (Meng et al., 2015; Kasahara and Li, 2020). There is a common belief that Mao Zedong's government, misguided by inflated production reports from local officials, procured/exported too much grain by accident. However, documents recently found in national archives call this into question. In particular, historian Frank Dikötter (2010) discovered the minutes of a top secret meeting of party leaders in which "He [Mao] himself encouraged much greater procurement than usual, at a time when it was well known that the crop figures had been inflated" (p. 252). This and other documents found by Dikötter (2010) show that "[t]he idea that the state mistakenly took too much grain from the countryside because it assumed that the harvest was much bigger than it was is largely a myth" (p. 252). Mao is aware that people are starving, but instead of providing famine relief (e.g., grain imports) he orders policies that exacerbate the famine: he increases grain procurement and exports, accelerates debt repayments to the Soviet Union, and sends food aid to foreign countries. Why, is the great unsolved puzzle of China's Great Famine.

This article asks if Mao *benefited* from famine and thus had incentives to let people starve. More generally, I inquire when a central planner would want to reduce the economy's labor force. My point of departure is the Lewis-Ranis-Fei (LRF) dual-sector model (Lewis, 1954; Ranis and Fei, 1961). There is a traditional agricultural sector with *surplus labor* (i.e., the marginal product of labor is zero) and a modern industrial sector. The capacity of the industrial sector to absorb agricultural surplus labor increases with the amount of industrial capital. In the LRF model, savings of the *industrial* sector are assumed to be the source of industrial capital accumulation hence migration and economic growth.

Numerous articles investigate China's economic growth through the lens of the LRF model (see Athukorala and Wei 2018 for a review), but they focus on the post-Mao era, i.e., after market-oriented policy reforms started in the late 1970s. On the eve of China's Great Famine, however, the Chinese economy differed in important aspects from the LRF model. First, China was a *centrally planned* economy. Second, savings of the *agricultural* sector (grain exports), not the industrial sector, were the source of industrial capital (imports of industrial equipment): China imported most of its first modern industrial equipment during the Great Leap Forward (1958-1962) in exchange for Chinese grain (Dikötter, 2010, ch. 10). In their seminal articles, both Lewis (1954) and Ranis and Fei (1961) are silent about the origin of the *first* industrial capital. Both implicitly assume that there is some exogenous initial capital endowment. Without this endowment or "start capital", industrial production is zero, hence there are no savings to set in motion the virtuous circle of capital accumulation, migration, and economic growth of the LRF model. A more realistic model would account for the fact that the start capital must come from the savings of the agricultural sector (unless there is a foreign lender or donor).

I modify the LRF model as follows: first, I assume that savings of the agricultural sector (e.g., grain exports), not the industrial sector, are the source of industrial capital (e.g., imports of industrial equipment). Furthermore, instead of laissez-faire, there is a rational central planner whose objective is to maximize industrial output, who pays a subsistence wage to the labor force, and who allocates labor across sectors.

I find that a marginal reduction in the economy's labor force (e.g., through famine) can *increase* industrial output. Intuitively, the central planner's optimal strategy is to allocate all surplus labor to the industrial sector and to use agricultural savings (agricultural production minus wage bill) to purchase industrial capital. Consequently, if there is a reduction in the labor force (surplus labor), agricultural output is unchanged but the central planner's wage bill is smaller, resulting in higher agricultural savings hence more industrial capital. The less-populous economy, therefore, has *more industrial capital but fewer industrial labor*, and industrial output is higher if the positive effect of additional capital exceeds the negative effect of fewer labor. This is plausibly the case when industrialization is in its infancy, i.e., when there is still few industrial capital hence the marginal product of industrial capital is high. Following Ranis and Fei (1961), I opt for an intuitive schematic presentation of the model (Figure 1). This schematic presentation, in my view, provides a compelling visualization of the main argument of this article: If there is surplus labor and agricultural savings are the source of industrial capital, then a reduction in the economy's labor force (e.g., through famine) increases agricultural savings, which the central planner can invest in the industrial sector.

Previous research by historians and novel econometric analysis conducted in this article suggest that this modified LRF model provides a realistic description of China on the eve of the Famine. Mao's obsession with industrial output (in particular steel) is well-known. That he imported modern industrial equipment (e.g., steel mills, cement kilns, power stations, oil refineries) from abroad in exchange for Chinese grain is also well-documented. Furthermore, in public speeches and conversations with confidants, Mao indicated his willingness to sacrifice lives in order to transform China into an industrial power.

While there is consensus that "[t]here was ample surplus labour" (Athukorala and Wei, 2018, p. 422) when the market-oriented reforms started in the late 1970s, I am not aware of quantitative research investigating if the Chinese economy exhibited surplus labor *on the eve of the Great Famine*, i.e., econometric estimates of the marginal product of agricultural labor in the 1950s. To fill this gap, I estimate a grain production function, regressing a province's annual grain production on production inputs, drawing on data compiled my Meng et al. (2015). I use the estimated regression coefficients to predict the marginal product of agricultural labor for the period 1949-1957. I find that the predicted marginal product is often close to zero in the pre-famine years, i.e., that surplus labor existed. Furthermore, using a difference-in-differences strategy, I find that when a province has surplus labor, its rural population subsequently decreases, which is consistent with the hypothesis that surplus labor is reallocated to industry. I also find that this decrease in the rural population has no impact on agricultural output, which further corroborates the hypothesis that there is surplus labor.

If the model provides a realistic description of China on the eve of the famine, this means that famine mortality contributed to Mao's goal of transforming a poor agrarian economy into an industrial power, i.e., that Mao had incentives to let people starve.

This article makes at least five contributions. First, the hypothesis that Mao *deliberately* let people starve is a novel yet reasonable hypothesis given that famine was a popular political tool in the first half of the 20th century. For example, recent research provides compelling empirical evidence that Mao's mentor Stalin deliberately starved millions of Ukrainians in 1932-33 in order to take control of Ukrainian grain production (Markevich et al., 2021; Naumenko, 2021).[1]

Second, while numerous articles investigate China's economic growth in the post-Mao era through the lens of the LRF model, I offer a dual economy model that captures the basic features of the Chinese economy on the eve of the Great Famine (central planning, agricultural savings are the source of industrial capital), which may advance our understanding of economic growth in the Mao era.

Third, I show that a reduction in the labor force can increase economic growth in this dual economy model, which is a surprising result given that labor is a production factor in the LRF model, my adapted LRF model, and every other textbook model. This may also explain why the hypothesis that Mao deliberately let innocent people starve, and famine as an economic growth policy more generally, has received little attention thus far. As a policy, famine has until now been mainly associated with *ethnic cleansing* (Markevich et al., 2021; De Waal, 2017; Erichsen and Olusoga, 2010). However, the link between famine and *industrialization* has been largely ignored thus far by scholars of famine, economic growth, and political violence. This article contributes to fill this gap.

Fourth, to my knowledge this manuscript provides the first econometric estimates of the marginal product of agricultural labor on the eve of the Famine, i.e., for the period 1949-1957 (Islam and Yokota 2008 conduct a similar exercise, but for the period 1989-2005). These estimates and additional empirical evidence (using a difference-in-differences strategy) suggest that the Chinese economy exhibited surplus labor on the eve of the Famine.

Finally, my analysis complements several recent articles. Meng et al. (2015) and Kasahara and Li (2020) find that excessive grain procurement and exports by the Chinese government were chief causes of famine mortality. My results provide a rational explanation for why grain procurement/exports were "excessive" and "inflexible": famine mortality contributed to Mao's goal of becoming an industrial power. My work is also related to Li and Yang (2005), who study the Chinese Famine through the lens of a dynamic model of central planning. Their key assumption is that the central planner is *irrational* (i.e., impatient and myopic): he diverts too much resources from agriculture to industry, unable to foresee (by assumption) the Famine. In their model, a rational central planner would not have caused the Famine. In my model, a *fully rational* central planner has incentives to create a famine because a reduction in the economy's labor force (surplus labor) increases agricultural savings hence industrial capital and thus industrial output. My work is further related to Gregory et al. (2011) and Dower et al. (2021), who show that dictators can consolidate power by killing innocent civilians. I show that killing innocents can increase the pace of economic development (industrialization). More generally, my results contribute to the literature on the political economy of autocracy, which is less studied and understood than democracy,

[1]Other examples include German Emperor Wilhelm II, who deliberately starved the Herero and Nama tribes (1904-1908) in order to take control of their land (Erichsen and Olusoga, 2010), the Young Turks starved the Armenians (1915-1917) as a means of ethnic cleansing (Lehmann, 2021), and Hitler starved millions of Poles (1941–1944) in order to feed his army (De Waal, 2017).

even though autocracies still account for almost one-half of the world's current population (Egorov and Sonin, 2011).[2]

2. Background, literature review, and the puzzle

Chronicle. In 1949, after more than twenty years of guerrilla warfare, the Chinese Communist Party overthrows the ruling government of Chiang Kai-shek and establishes the People's Republic of China. From 1955-1958, Mao collectivizes agricultural production: private property is turned over to the communal government, and production is guided by government targets. By the end of 1958, China counted 24,000 agricultural communes consisting of 120 million households (99 percent of rural households in China in 1958 (Lin, 1990)).

In 1957, in response to Khrushchev's announcement that the Soviet Union will surpass the United States in GDP within fifteen years, Mao announces that China will surpass Great Britain in steel production over the same period. The slogan "going all out, aiming high, and achieving more, faster and more economical results" or "Great Leap Forward" become emblematic of Mao's quest to transform a poor agrarian economy into an industrial power. As a result, the government's procurement of grain increases far above previous levels in order to finance, through grain exports, the import of vast quantities of industrial equipment (e.g., steel mills, cement kilns, glass factories, power stations, oil refineries), see Dikötter (2010, ch. 10). At the same time, Mao launches a campaign of repression against party members critical of his industrialization policies.

Between 1959 and 1961, between 16.5 to 45 million people die of famine, mainly in rural areas.[3]

Literature review. The existing literature identifies a number of causes for the Famine. Lin (1990) argues that collectivization drastically reduced work incentives of peasants. Relatedly, Chen and Lan (2017) document how peasants consumed their livestock to avoid having to share it with the collective, which in turn reduced grain output by reducing the quantity of animal inputs (e.g., draft animals). Yao (1999) argues that poor weather, excessive planting (e.g., planting seeds so close that there is no room for the plant to grow), and diversion of agricultural inputs to steel production also explain part of the reduction in grain output. Relatedly, Kueh (1995) argues that bad weather contributed to lower agricultural output. Yang (1996) argues that communal projects (e.g., irrigation projects) involved highly energy-consuming activities, thereby raising the level of caloric intake. Both Yang (1996) and Chang and Wen (1997) argue that communal dining halls aggravated the famine by distributing too much food.

Lin and Yang (2000) conduct the first statistical (i.e., regression) analysis, using province-level panel data, and find that both per capita grain output (a proxy for food availability) and percentage of urban population (a proxy for "urban bias" in food distribution) are associated with fewer deaths. Kung and Lin (2003) find a positive correlation between deaths and

[2]See, for example, Wintrobe (2000), Overland et al. (2005), De Mesquita et al. (2003), Acemoglu and Robinson (2006). Gehlbach et al. (2016) provides a detailed review of the literature.

[3]Mortality estimates range from 16.5 million (Coale, 1981), to 30 million (Banister, 1987), to 45 million (Dikötter, 2010).

government grain procurement. Kung and Chen (2011) and Fan et al. (2016) suggest that excessive grain procurement was partially driven by career incentives of local government officials. Li and Yang (2005) find a negative correlation between steel and grain output (consistent with the hypothesis of diversion of agricultural inputs to steel production). Meng et al. (2015) identify inflexible and progressive government procurement as a key factor, and Kasahara and Li (2020) stress the role of excessive grain exports.

The puzzle. Dikötter (2010) recently debunked the common belief that Mao's government, misguided by inflated production reports from local officials, procured too much grain by accident. In a top secret meeting of party leaders, Mao himself encouraged much greater grain procurement and exports than usual, at a time when it was well known that the crop figures had been inflated and people had started talking of famine. Mao also pushed for accelerated debt repayments to the Soviet Union: Between 1960 and 1962, as tens of millions of Chinese die of famine, China payed off 1.3 billion rubles of its 1.4 billion rubles debt, and cleared its debt entirely by 1965 (Dikötter, 2010, p. 208). Furthermore, Mao increased food aid to other countries. Overall, Mao provided aid worth 4 billion yuan to foreign countries. Albania's Representative in Beijing later recalled that he could see the signs of famine in Beijing, but "the Chinese gave us everything (...) I felt ashamed" (Dikötter, 2010, p. 222).

Mao's apparent indifference to mass starvation is striking. In the words of Mao's personal physician: "Mao knew that people were dying [starving] by the millions. He did not care." (Li, 1994, p. 300). Why, is the great unsolved puzzle of China's Great Famine.

3. Theory

Did Mao have incentives to let people starve? Specifically, did famine mortality contribute to Mao's goal of transforming a poor agrarian economy into an industrial power? The starting point of my inquiry is the canonical dual-sector model.

The canonical dual-sector model (*laissez-faire*). In the Lewis-Ranis-Fei model (Lewis, 1954; Ranis and Fei, 1961) there is a traditional agricultural sector with *surplus labor* and a modern industrial sector; the capacity of the industrial sector to absorb surplus labor increases with its capital; savings of the modern sector are the source of capital accumulation hence migration and economic growth. Panel (a) of Figure 1, which is based on Ranis and Fei (1961) and Ray (1998), provides a schematic description of the canonical model: the bottom graph shows the agricultural sector, i.e., an agricultural production function with surplus labor (the flat part of the function) and the agricultural wage bill; the top graph shows the industrial sector, i.e., the marginal product and wage of industrial labor. The marginal product of industrial labor increases with the amount of industrial capital, hence the three marginal product curves MPL_1, MPL_2, and MPL_3 show the marginal product of industrial labor for increasing amounts of industrial capital. On the x-axis, the industrial labor force is read from left to right and the agricultural labor force is read from right to left. The width of the x-axis corresponds to the entire labor force.

To see how the canonical model works, suppose that the entire labor force is in the agricultural sector (point A). At that point, agricultural wages are assumed to be determined by income sharing (e.g., a household divides its harvest equally among household members).

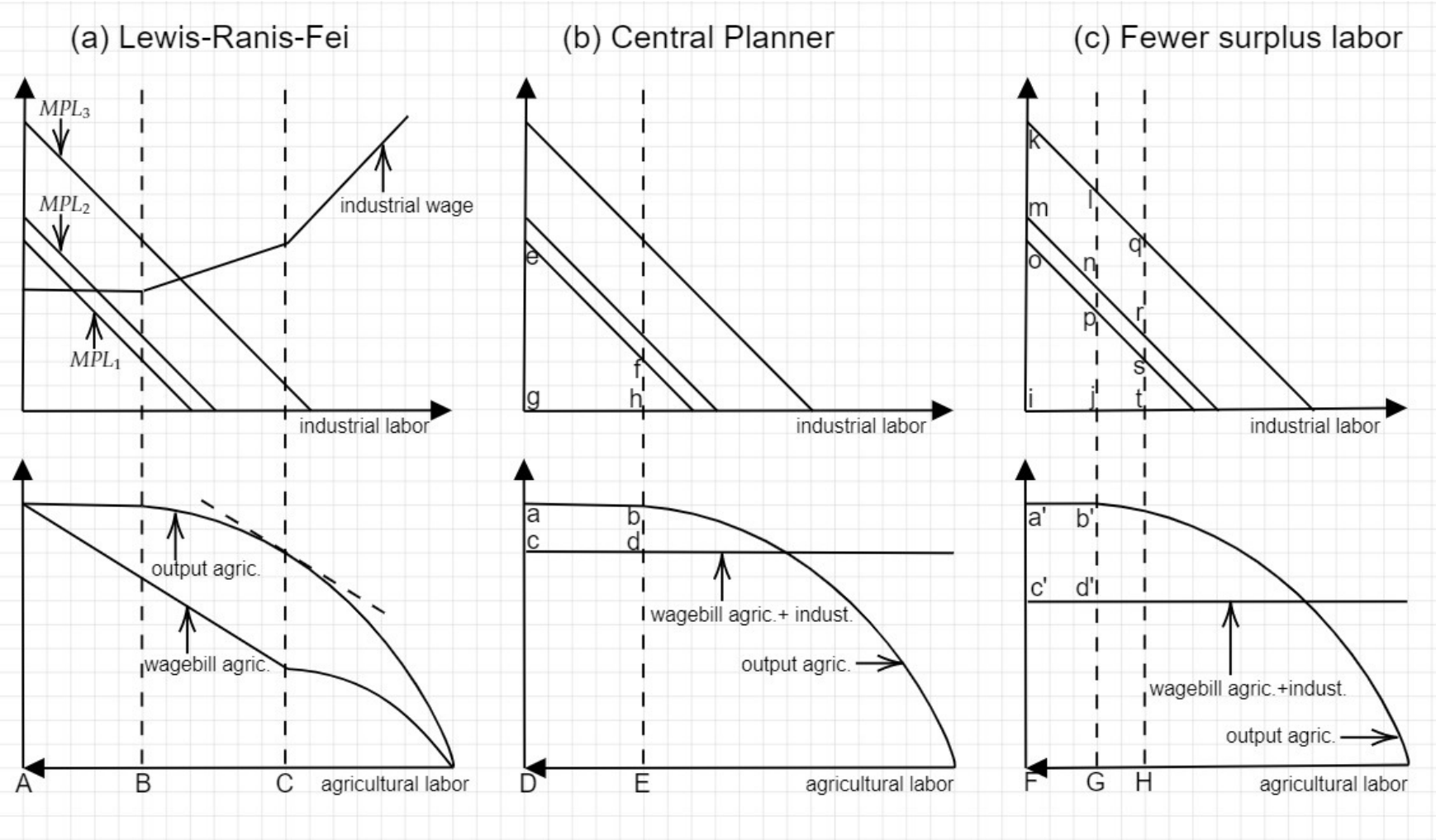
In other words, the agricultural wage equals the average product, not the marginal product. Now transfer some labor from agriculture to industry such that we remain on the flat part of the agricultural production function: as a result, the agricultural wage bill falls while agricultural output remains unchanged. Each transferred laborer must be able to buy back the amount of agricultural goods she consumed while being employed in the agricultural sector. The industrial wage needed for this is shown in the top graph. As long as we are on the flat part of the agricultural production function, the industrial wage does not change because agricultural output is not changing. However, once all surplus labor is transferred to industry (point B), additional transfers reduce agricultural output. At the previous industrial wage, these additional transfers will not be able to buy the food they consumed as agricultural workers because food supply declined, hence the industrial wage must rise as compensation. Continue the transfer of labor until the marginal product of agricultural labor equals the traditional agricultural wage (point C). From now on additional transfers create a situation where agricultural labor's marginal product exceeds its cost, thus the agricultural sector starts bidding for labor (which Ranis and Fei 1961 call the "commercialization" of agriculture). Consequently, wages in agriculture and industry increase.

Capital accumulation in the *industrial* sector is assumed to be the source of migration and economic growth: industrial profits are partly plowed back as extra capital in the industrial sector, which further increases demand for industrial labor (e.g., from MPL_1 to MPL_2 in the top graph). As migration from agriculture to industry continues, the terms of trade gradually turn against industry: food prices hence industrial wages rise. The economy's ability to feed the industrial labor force limits the pace of industrialization.

A populous centrally planned dual economy. Numerous articles, as previously mentioned, investigate China's economic growth through the lens of the Lewis-Ranis-Fei model (see Athukorala and Wei (2018) for a review), but they focus on the post-Mao era, i.e., after market-oriented policy reforms started in the late 1970s. On the eve of China's Great Famine, however, the Chinese economy differed in important aspects from the canonical model. First, China was a *centrally planned* economy. Second, savings of the *agricultural* sector (grain exports), not the industrial sector, were the source of industrial capital (imports of industrial equipment). As previously mentioned, China imported virtually all of its first modern industrial equipment during the Great Leap Forward period in exchange for Chinese grain (Dikötter, 2010, ch. 10). In their seminal articles, both Lewis (1954) and Ranis and Fei (1961) are silent about the origin of the *first* industrial capital. Both implicitly assume that there is some exogenous initial capital endowment. Without this endowment or "start capital", industrial production is zero, hence there are no savings to set in motion the virtuous circle of capital accumulation, migration, and economic growth of the Lewis-Ranis-Fei model. A more realistic model would account for the fact that the start capital must come from the savings of the *agricultural* sector (unless there is a foreign lender or donor).

Panel (b) of Figure 1 depicts a centrally-planned economy. Agricultural savings are assumed to be the source of industrial capital. I further assume that the central planner allocates labor across sectors and pays a subsistence wage in the form a food parcel (i.e., a fraction of agricultural output) to each laborer. The laissez-faire wages of Panel (a) thus disappear and the wage bill of the entire labor force (agriculture and industry) is given by

Figure 1: Incentives to let people starve in a centrally planned dual economy



Notes: Panel (a) is based on Ranis and Fei (1961) and Ray (1998).

the horizontal line in the bottom graph. Savings of the agricultural sector is the difference between agricultural production and the wage bill.

Suppose that the entire labor force is in the agricultural sector (point D). Now transfer some labor from agriculture to industry such that we remain on the flat part of the agricultural production function: both agricultural production and savings remain unchanged as a result. Only once all surplus labor has been transferred to industry (point E) will further transfers decrease agricultural savings. The central planner uses agricultural savings (e.g., grain exports) to acquire industrial start capital (e.g., import industrial equipment).

The central planner allocates all surplus labor to industry (point E) because this maximizes agricultural savings $(b - d)$ hence industrial start capital. Suppose that the marginal product of labor with this start capital is given by MPL_1, hence industrial output is given by the area of the trapezoid *gefh*.

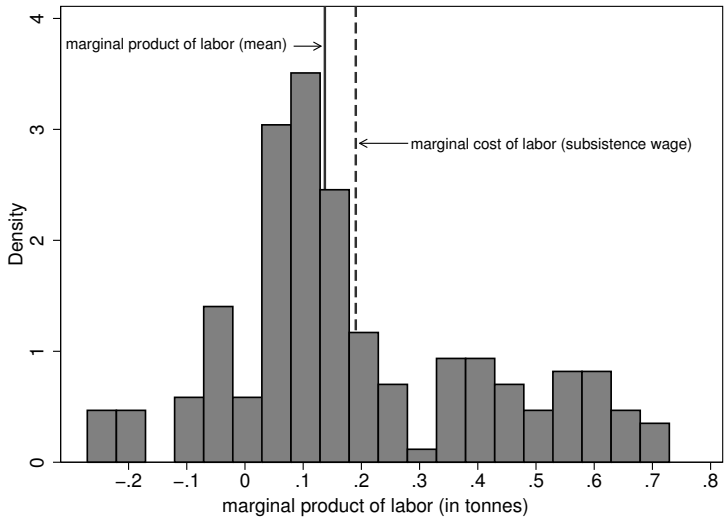
A less-populous centrally planned dual economy. What happens to industrial output if the labor force declines? Panel (c) shows the same centrally-planned economy as in Panel (b), but with a smaller labor force (the x-axis is shorter compared to Panel (b)), hence with fewer surplus labor and a smaller wage bill. The central planner allocates all surplus labor to industry (point G), where agricultural savings $(b' - d')$ are larger compared to the more populous economy $(b - d)$, resulting in *more capital but less labor* in the industrial sector. Industrial output is higher if the additional capital has a sufficiently large impact on the marginal product of labor. For example, if the marginal product of labor is given by MPL_3, then industrial output is given by the area *klji*, which is larger than the area *efgh* in Panel (b); specifically, the gain in industrial output from more capital (*klpo*) is larger than the loss from fewer labor (*pstj*).

4. Evidence

This section draws on historical data and econometric analysis to assess in how far the populous centrally planned dual economy fits the Chinese economy on the eve of the Famine, i.e., in how far Mao had incentives to let people starve (reduce the labor force) in order to increase industrial output. The key tenets of the model are (a) a central planner whose objective is to maximize industrial output and who is willing to sacrifice lives for it; (b) savings of the agricultural sector are the source of the first industrial capital; and (c) surplus labor in the agricultural sector, which the central planner allocates to the industrial sector.

A cold-blooded central planner who wants to maximize industrial output. On several occasions Mao indicated his willingness to sacrifice the life of millions of citizens to achieve his goals. Mao frequently asserted "*Bu po, bu li!*", there is no construction without destruction (Schram, 1994). The memoirs of Mao's personal physician, who during twenty-two years (1954-1976) was "at his side almost constantly, whether in Beijing or elsewhere" (Li, 1994, p. 29), are particularly revealing. According to his physician, Mao "was devoid of human feeling, incapable of love, friendship, or warmth", and would frequently say that "lives have to be sacrificed for the cause of the revolution" (ibid., p. 288). Mao identified with the most cruel of China's emperors, such as Emperor Zhou (who killed people that were against

Figure 2: Surplus labor in Chinese provinces on the eve of the Famine (1949-1957)



Notes: The graph shows a histogram of the marginal product of agricultural labor (province-level) in the pre-famine years. To estimate the marginal product of agricultural labor, I follow Meng et al. (2015, pp. 1581-82) and estimate a grain production function, regressing a province's annual grain production on the following production inputs: rural population and its squared term, total land area and its squared term temperature and its squared term, rainfall and its squared term, grain suitability and its squared term, and all combinations of the double interactions of temperature, rainfall, suitability, rural population, and total land area. I use the estimated regression coefficients to predict the marginal product of rural labor in each province in a given year. I focus on the pre-famine years (1949-1957). Figure 2 shows a histogram of these estimates. The vertical line at 0.14 tonnes shows the mean across provinces. The dashed line at 0.19 tonnes is a measure of the marginal cost of labor, i.e., the annual amount of grain that an agricultural laborer requires for subsistence: 1kg of grain provides 3,587 calories (Meng et al., 2015), hence the annual grain requirement for subsistence, assuming a calorie requirement of 1,871 per day (Meng et al., 2015), is $1871 \times 365/3587 = 190.4$kg.

Zhou's goal of territorial expansion) or Qin Shihuangdi (who executed Confucian scholars because they got in his way). "He only killed 260 Confucian scholars. Where was the great tragedy in that? One ought not, in looking at Qin Shihuangdi, exaggerate the trivial and ignore the great", Mao said (ibid., p. 293).

Mao's and other socialist leader's "obsession" with industrial growth is also well-documented (e.g., Gros and Steinherr (2004, ch. 2)). Mao's desire to strengthen national defense on the basis of metallurgy, machine building and heavy industry, and the need to foster growth through heavy industrialization, and perhaps also the desire to forestall political dissent (Olson, 1986), were important drivers of this obsession. In October 1957 Mao declared: "Comrade Khrushchev tells us that the Soviet Union will overtake the United States in fifteen years. I can tell you that in fifteen years we may well catch up with or overtake Britain" (Dikötter, 2010, p. 48). Mao was particularly possessed by steel, seeing it as the fundamental indicator of economic development: "Our country produces too little steel (...) We have to do everything we can to increase our material strength. Otherwise, people will look down on us" (Li, 1994, p. 511). Mao consequently increased China's steel production target from

5 million tonnes in 1957, to 12 million tonnes in 1958 (Dikötter, 2010, p. 125).

Savings of the agricultural sector are the source of industrial capital. From the moment Mao declared to overtake Britain in fifteen years, he ordered massive imports of industrial equipment. Between 1958 and 1959, imports from the Soviet Union rose by 60% (from 556 million rubles in 1957 to 881 million in 1958), from Great Britain by 125% (from £12 million in 1957 to £27 million in 1958), from West Germany by 240% (DM 200 million in 1957 to DM 682 million in 1958). All of these imports were industrial capital goods (e.g., steel mills, cement kilns, power stations, oil refineries). Due to China's limited foreign currency and gold reserves, these imports had to be paid for through agricultural exports and debt. For example, the value of the rice exported to Moscow trebled from 1957 to 1959 (Dikötter, 2010, ch. 10).

Surplus labor in the agricultural sector. Econometric analysis suggests that many Chinese provinces had surplus labor on the eve of the famine. Figure 2 shows that the marginal product of rural labor was close to zero in the majority of provinces in the pre-famine years. To estimate the marginal product of agricultural labor, I follow Meng et al. (2015, pp. 1581-82) and estimate a grain production function, regressing a province's annual grain production on the following production inputs: rural population and its squared term, total land area and its squared term temperature and its squared term, rainfall and its squared term, grain suitability and its squared term, and all combinations of the double interactions of temperature, rainfall, suitability, rural population, and total land area.[4] I use the estimated regression coefficients to predict the marginal product of rural labor in each province in a given year. I focus on the pre-famine years (1949-1957).[5] Figure 2 shows a histogram of these estimates. The vertical line at 0.14 tonnes shows the mean across provinces. The dashed line at 0.19 tonnes is a measure of the marginal cost of labor, i.e., the annual amount of grain that an agricultural laborer requires for subsistence.[6] Thus, on average, the marginal product of rural labor was close to zero and below marginal cost in the pre-famine years.

Reallocation of surplus labor. Table I presents evidence that surplus labor is allocated to industry. It shows the results of the following difference-in-differences specification:

$$Y_{it} = \beta SL_{it} + \theta_i + \theta_t + \epsilon_{it} \tag{1}$$

where SL_{it} indicates if province i has surplus labor in year t (i.e., $SL_{it} = 1$ if the marginal product of agricultural labor is zero or negative, and $SL_{it} = 0$ otherwise), and θ_i and θ_t are province and year fixed effects, respectively.

[4] Meng et al. (2015) estimate the same production function, using the years 1949-1957 and 1962-1982 (i.e., excluding the famine years), to predict grain production for the famine years (i.e., to get a production measure that is purged from the over-reporting that occurred during the famine years).

[5] Islam and Yokota (2008) conduct a similar exercise, but for the period 1989-2005.

[6] 1kg of grain provides 3,587 calories (Meng et al., 2015), hence the annual grain requirement for subsistence, assuming a calorie requirement of 1,871 per day (Meng et al., 2015), is $1871 \times 365/3587 = 190.4$ kg.

Table I: Difference-in-differences estimates

	Dependent variable:	
	(log) rural population	(log) grain output
	(1)	(2)
Surplus labor dummy	-0.047**	-0.009
	(0.022)	(0.019)
Province fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Number of observations	160	160
R^2	0.06	0.22

Notes: The surplus labor dummy indicates if the marginal product of agricultural labor in province i is zero or negative in year t. Column (1) shows OLS estimates of regressing log rural population of a province (the dependent variable) on the surplus labor dummy, controlling for province and year fixed effects. The time period is 1949-1957. In Column (2) the dependent variable is log grain output.
*,**,*** significant at ten, five, and one percent, respectively. Robust standard errors, clustered at the province level, in parentheses.

Column (1) shows OLS estimates of β when the dependent variable, Y_{it}, is log rural population of province i in year t. Intuitively, β measures the change in the rural population when a province's marginal product of agricultural labor turns zero or negative (treatment group), minus the change in the rural population of other provinces (comparison group). I find a statistically significant negative treatment effect (-0.047), i.e., the rural population falls by 4.7% when it exhibits surplus labor, which is consistent with the hypothesis that the central planner reallocates surplus labor from agriculture to industry.

In Column (2), the dependent variable is log grain output. The point estimate in this case is zero, which is again consistent with the existence of surplus labor, for the 4.7% reduction in the rural population (column 1) has no impact on agricultural output (column 2).

5. Conclusion

The evidence presented in the previous section is largely consistent with the populous centrally planned dual economy in section 3. If the model provides a realistic description of China on the eve of the famine, this means that famine mortality contributed to Mao's goal of transforming a poor agrarian economy into an industrial power, i.e., that Mao had incentives to let people starve. Mao's personal physician writes that "it was not until the Great Leap Forward, when millions of Chinese began dying during the famine, that I became fully aware of how much Mao resembled the ruthless emperors he so admired. Mao knew that people were dying by the millions. He did not care." (Li, 1994, p. 300). In this article, I offered a rational explanation for Mao's indifference: famine mortality furthered Mao's objective of transforming a poor and populous agrarian society into an industrial power.

When is it optimal for a political leader to let innocent citizens starve? It is a question that is relevant beyond China's Great Famine. The answer may advance our understanding of

famines, and perhaps allow the international community to save the lives of innocent citizens in the future. Today, there are numerous developing countries ruled by authoritarian regimes who perhaps perceive the country's large number of peasants as an impediment to economic development.[7] When famine strikes in these countries, should the international community be prepared to help the peasants because their government may find it optimal not to? The focus of this article is on centrally planned economies, a promising avenue of future research is to investigate incentives of authoritarian regimes in laissez-faire economies to let people starve.

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[7] E.g., Burundi, Cameroon, Central African Republic, Chad, Republic of Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Rwanda, Somalia, Sudan, Uganda, among others.

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