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Finance and Hunger:

Empirical Evidence of the Agricultural Productivity Channel

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Abstract: We show that financial sector development significantly reduces undernourishment (hunger). We find evidence of specific financial sector development channels, including increased access to productivity enhancing equipment—fertilizer and tractor use—translating into higher agricultural productivity and cereal yields, with accompanying beneficial income and general quantity and price effects. Results are robust to various specifications and econometric tests, including both cross-country and panel regressions, and using various control variables. They are economically large and imply that a 1 percent increase in private credit to GDP reduces undernourishment by 0.22-2.45 percent, or about one-quarter of the impact of GDP per capita on undernourishment.

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I. Introduction

Although most countries have experienced per capita growth in the 20th century, extreme income poverty and undernourishment is still widespread. In 2001, GDP per capita, corrected for purchasing power, in the world was on average about $21 a day. However, in the same year, more than half of the world population lived on less than $2 a day and more than 1 billion lived on less than $1 a day, whereas daily per capita income in a typical developed country exceeded $60. Income poverty is but one measure of (the lack of) development, another measure is the presence of hunger or undernourishment.[1] Unfortunately, undernourishment followed a similar, dispersed pattern. On average, about 20 percent of the world population was undernourished in the 1990s. However, undernourishment's prevalence was 70.5 percent in Eritrea, compared to 2.5 percent in Poland. Moreover, a lot of countries have eradicated undernourishment.[2]

A large literature is devoted to analyzing the links between economic growth, inequality, poverty and hunger. General findings are that higher growth and lower inequality are associated with lower levels of poverty and hunger. Another established literature has found robust evidence that financial sector development spurs economic growth, primarily because it puts capital to its most productive use. Moreover, this line of research shows that financial development reduces inequality because it levels the playing field and enables (poorer) individuals and (smaller) firms to participate in the formal economy and grow. New research has tied together these two literatures and found beneficial relationships from financial sector development to poverty reduction.

[1] One is considered undernourished when one's food intake falls below the minimum requirement or when one's food intake is insufficient to meet dietary energy requirements continuously. During the Millennium Summit in September 2000, 189 nations unanimously adopted the Millennium Declaration. The Declaration contains eight specific Millennium Development Goals (MDGs). The main aim of the Declaration is to eradicate extreme poverty around the world by 2015. As such, the MDGs are the most ambitious and most broadly supported development goals the world has ever established. One of the most important is the Poverty-MDG, which consists of two parts: 1) reduce income poverty by cutting in half the fraction of the population who live on less than 1$ a day and 2) reduce hunger by cutting in half the fraction of the population who suffer from undernourishment.

[2] Of the 171 countries for which we have GDP per capita data, all but one of the 29 countries with GDP per capita higher than $16,000 have no undernourishment (the exception is United Arab Emirates, which has a 3% prevalence of undernourishment).

These findings raise the question whether relationships also exist between financial development and undernourishment and how these may come about. More specifically, the question arises whether there is evidence of a beneficial relationship between financial development and both Millennium Development Goals (MDG) indicators of poverty, i.e., not just income poverty but also undernourishment; and if so, what are the specific channels through which financial sector development improves undernourishment? In this paper we investigate these two questions.

We focus on undernourishment which is defined as: "the condition of people whose dietary energy consumption is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out a light physical activity" (FAOSTAT, 2006). Reducing undernourishment can be regarded as the first and foremost development objective, since not being undernourished defines a person's chances of living. Measuring the prevalence of undernourishment involves the comparison of actual household food consumption (expressed in terms of calories per person per day) with a minimum dietary energy requirement (also expressed in terms of calories per person per day) and then the classification of those individuals with per capita calorie consumption levels below the minimum requirement as being undernourished. Obviously, undernourishment is related to the prevalence of extreme poverty, but there are distinctive differences. Whereas the measure of the prevalence of undernourishment is based on the distribution of actual household food consumption and availability, the (World Bank) measure of the prevalence of extreme poverty is based on the distribution of household income (or consumption), adjusted for purchasing power. Undernourishment and poverty can differ, not only because of relative prices which mean a certain income level does not translate in an ability to attain oneself of sufficient food, but also because of insufficient availability of food, as when faced with permanent or temporary insufficient local production.

Our findings can be summarized as follows. Using cross-country OLS, instrumental variables and panel regressions for the period 1980-2003, we find a causal relationship from financial sector development to reduced undernourishment. Our results imply that a

1 percent increase in private credit to GDP (our main proxy for financial development) reduces the prevalence of undernourishment by 0.22-2.45 percent. Importantly, we find evidence of a specific channel: financial development increases agricultural productivity. We specifically show evidence of increases in livestock production, cereal and crop yields, which in turn lead to less undernourishment. Furthermore, we find evidence that the productivity increase channel operates through greater use of productivity enhancing equipment like tractors and fertilizers. As farmers become more productive by being able to finance more machinery or use more fertilizers, our analysis suggests that a 1 percent increase in private credit to GDP increases value added per worker by 0.14-1.7 percent. In turn, higher productivity leads to lower undernourishment. We find that a 1 percent increase in value added per worker reduces the prevalence of undernourishment by 0.41 to 0.8 percent.

Our conclusions remain with the inclusion of country controls which are known for their impact on poverty, financial development and hunger: initial levels of poverty and GDP per capita, average inflation, average trade openness, the fraction of the working population in the agricultural sector, and the fraction of the population in rural areas. The results also prevail when using panel estimation techniques. We furthermore find some support for the fact that it is not just financial sector development that matters, but also that the outreach of the banking system distribution network matters specifically for reducing undernourishment, suggesting that access to financial services is important.

Our results, though robust to many different specifications, do come with some provisos. As for many other studies, we have only rough measures of financial sector development—we use private credit to GDP as a proxy, and thus do not capture access to financial services for poor and undernourished households directly. We cannot establish *how* exactly people use financial services to decrease undernourishment and in a definite way the exact channel driving the increase in productivity. This has been done on a country-specific micro basis, however, using household and firm surveys and other micro-evidence, which tends to corroborate the importance of access to financial services to reducing undernourishment. While our cross-country application complements this

work, more research is needed to pinpoint whether the specific channels apply similar across countries or whether certain country characteristics and policies affect the impact of financial sector development on undernourishment.

The remainder of the paper is structured as follows. Section II briefly reviews the related literature and lays out our hypothesis. Section III discusses the data and our methodology. Section IV presents the results and Section V concludes.

II. Related Literature and Hypothesis

There are a large number of papers which describe the links between growth, equality, poverty, and financial development. We classify these papers in three separate groups: 1) economic growth, equality, and poverty, 2) financial development, growth and inequality, and 3) financial development and poverty. Using this literature, we develop hypotheses and empirical tests through which channels we can expect financial development to affect the prevalence of undernourishment.

A. Economic growth, equality, and poverty

Research has shown close links between economic growth and income poverty and between inequality and income poverty. One piece of evidence on the importance of growth is that the poorest share in the benefits of overall economic growth. Dollar and Kraay (2001) show that both overall income per capita and growth rate of income per capita are highly associated with the level of income of the poorest quintile and the growth rate of their income. They show that growth in overall income per capita explains over 80 percent of the variation in the growth of the income of the lowest quintile. The poor thus benefit from growth, i.e., they do share in overall growth. And the effect is substantial. Besley and Burgess (2003) find that it would require a 2.1 percent increase in per capita world growth rate from 1990 on to cut world poverty in half by 2015, where poverty is defined as living on less than 1$ per day (in 1983 US$, corrected for purchasing power). This importance of general economic growth does not negate the relevance of inequality in reducing poverty. Besley and Burgess (2003) confirm that less

inequality leads as well to a significant reduction in poverty. If one could diminish world inequality with one standard deviation without sacrificing growth, poverty would be reduced by 67 percent.[3] In all, these findings imply that both growth and reduced inequality have large effects on poverty.

B. Financial development, economic growth and inequality

Another large empirical literature has established that financial development spurs economic growth (much of this started with King and Levine, 1993; for an overview of the literature, see Levine 2005) and decreases inequality. The latter finding may not be obvious. Some theoretical studies argue that only the rich benefit from financial development because only they have access to financial services. Others (Banerjee and Newman 1993, Greenwood and Jovanovic 1990 and Aghion and Bolton 1997) argue that only in a later stage of development do the poor also get access. And others argue that the beneficial effects of financial development for the poor come about in an indirect way, even when they do not have direct access to financial services. Empirically, research finds that financial development not only increases growth, but also reduces inequality. The effect of financial development on inequality, as measured by the Gini inequality coefficient, is large and stronger for countries with greater financial development (as measured by more private credit) (Clarke, Xu, and Zou 2003). New research has found that financial development also *accelerates* the decline in inequality. Cross-country evidence shows that an increase in private credit to GDP leads to a faster decline in the Gini coefficient (Beck, et al. 2005), even more so in countries with initially high inequality. Moreover, the effect of private credit is strong even after the general level of development (as proxied by GDP per capita growth) is taken into account. This suggests that financial development has a disproportionate effect on inequality reduction.

C. Financial development and poverty

The reasons why financial sector development may matter specifically for poverty are well known: greater access to financial services enables poor people to plan better for the

[3] See further Barro (2000), Banerjee and Dufflo (2003) and Forbes (2000) for the relationships between inequality and growth.

future and invest in productivity enhancing assets. In accumulating financial assets and availing themselves of insurance to smooth their income, households can reduce the impact of unfortunate events like drought, disease or death that are part of daily life in developing countries. In addition, better income stability prevents households from being forced to sell off productive assets following adverse shocks, inducing an otherwise vicious spiral.

Financial development could play an important role via both its growth and inequality channels. Research along the lines of King and Levine (1993) implies that if all countries would have had financial sectors in 1990 equal to the current average, there would have been additional yearly per capita GDP growth of 0.7-0.9 percent. So in principle, financial development alone could lead to growth close to about half of the gap identified by Besley and Burgess (2003) needed to cut world poverty in half by 2015.

There is also other evidence that financial development is associated with a lower poverty ratio. Honohan (2003) analyzes relationships between levels of financial development and poverty and finds that a 10 percent increase in private credit to GDP reduces poverty ratios by 2.5-3 percent. This effect persists even when GDP per capita is taken into account, suggesting that, beyond its effects on income growth, financial development works via a reduction in inequality by broadening the opportunities of all to participate in productive economic activities. Beck et al. (2005) also find that financial development has a beneficial effect on the incomes of the poorest quintile of the income distribution. Furthermore, they find that financial development *accelerates* improvements in the poverty ratio: decreases in poverty are faster in countries that had faster growing ratios of private credit to GDP. Morduch and Haley (2002) provide detailed analyses of the effects of micro-finance on poverty reduction using more micro-based evidence, showing some of the channels.[4] See further Honohan (2004) for a review of the empirical work on the links between finance and poverty.

[4] Analyzing the growth of the poverty gap and financial development in that period produces similar results, where the poverty gap is the mean distance below the poverty line, expressed as a percentage of the poverty line, where the mean is taken over the entire population, counting the non-poor as having zero poverty gap. The measure reflects the depth of poverty as well as its incidence.

D. Hypotheses: The links between financial development and undernourishment

Since there exists a strong relationship between income poverty and undernourishment and since financial development reduces income poverty, financial development can be expected to reduce the prevalence of undernourishment largely via income poverty reduction. There is ample country-specific and other evidence that income poverty is the main cause of undernourishment. For example, in Indonesia during 1984-1987 rising income standards reduced malnutrition in the country and the fraction of people living at less than 1,400 calories declined with 26 percent (World Bank 1993).

Given these results, one would expect an impact of financial development on the prevalence of undernourishment, similar to that on poverty. Important though are the specific channels through which financial sector development affects undernourishment. In theory, some specific channels can be identified where financial sector development is especially important for undernourishment. First, access to financial services like savings and credit products may reduce undernourishment because it allows for consumption smoothing by poor households in the face of income and other shocks. Access to financial services makes agricultural workers less vulnerable to the impact of (economic) shocks, decreasing the need to inefficiently sell of their productive assets (e.g., cows, equipment), which would otherwise force them into a vicious spiral. Second, access to financial services (directly or indirectly) eases the financing of productivity improving agricultural equipment, thereby increasing agricultural yields and improving the income of those active in agriculture, thus reducing undernourishment. Third, there can be a link between financial development and undernourishment even when undernourished households do not gain (directly or indirectly) access to finance. One main reason is that higher agricultural productivity will translate into higher food output and lower food prices which is beneficial for all the poor, regardless whether they are active in agriculture or not. Similarly, to the extent financial sector development increases overall incomes, undernourishment will decline.

III. Data and Methodology

All our data are taken from the World Bank's World Development Indicators (2005). We start with using data averaged over all observations in the period 1980-2003 to diminish the effects of business cycle. We do, however, also use instrumental variables and panel data regressions as robustness tests. As we are not only interested in the effects of financial sector development on undernourishment, but also in the channels through which it happens, we conduct several analyses. First, we study the link between financial development and the prevalence of undernourishment. Second, we decompose this causal link by studying the link between agricultural productivity and undernourishment. Third, we study the link from financial development to overall agricultural productivity per worker and other specific agricultural productivity indicators. And fourth we decompose these links further by investigating the effects of financial sector development on use of productivity enhancing inputs requiring upfront layouts. Fifth, to investigate the importance of (direct) access to financial services, we study the effects of outreach of financial services on undernourishment, agricultural productivity, productivity enhancing inputs, and prices. To establish causation, we use an instrumental variables approach when necessary.

A. Variables and descriptive statistics

Table 1 presents the description of all the variables we use. Table 2 presents descriptive statistics of the variables which are central to our analysis: undernourishment, private credit to GDP, agricultural productivity, and the cereal yield.

Main variables

We have three main variables: undernourishment, private credit to GDP, and agricultural productivity. Our main LHS variable is the undernourishment, defined as the prevalence of undernourished people as a percentage of the total population. Undernourishment is only documented for the period 1980-2003, with most countries only having three observations in the 1990s: 1992, 1995, and 1998. In the basic sample, undernourishment is on average 19 percent, but varies widely over the world, ranging from 2.5 percent in

Poland to 57 percent in Burundi, with a standard deviation of almost 15. While most developed countries have very low values of undernourishment—it is zero in almost all developed countries, 25 percent of our sample has an undernourishment rate higher than 30 percent.

Following the literature, we proxy financial development by private credit to GDP, the value of credit extended by financial intermediaries to the private sector as a percentage of GDP. This measure excludes credits issued by the central bank and development banks, and credit to the public sector, credit to state-owned enterprises, and cross claims of one group of intermediaries on another. This comprehensive proxy is widely used and has been shown to be a driver of GDP per capita growth. Data on private credit is for most countries available for each year in the period 1980-2003: for 99 countries we have observations for each year. In the basic sample, private credit has an average value of 26 percent. However, there is wide variation: the minimum value is 2.9 percent and the maximum is 112 percent.

Overall agricultural productivity is defined as the yearly value added per agricultural worker, expressed in constant 2000 US Dollars. We have on average 20 observations per country for the period 1980-2003. The average level of agricultural productivity is about $1,800. However, there is wide dispersion, with a standard deviation of about $2,650. Rich countries have an average productivity of over $20,000, whereas poor countries may have productivity as low as $100.

Finally, to take a first step in assessing the importance of access to finance, we use the number of banking branches per 1,000 square kilometer from Beck, Demirgüç-Kunt, and Martinez Peria (forthcoming). These data are only available for 2003-2004. For about 100 countries, the average density of banking branches is 30 per 1,000 square kilometer, but this differs vastly between countries. Not surprisingly, large and developing countries tend to have a lower density. For example, the number of banking branches per 1,000 square kilometer in Ethiopia is less than 1. In contrast, Singapore has over 600 branches per 1,000 square kilometer.

Specific productivity measures

To further analyze the impact of financial sector development on agricultural productivity, we use three specific productivity measures: cereal yields per hectare of arable land, a crop production index and a livestock production index. The latter two indices have 1999-2001 as the benchmark year (=100) for all countries and the tests are conducted on how far the initial values are from 100, i.e., how high the growth rates have been over the period. We have wide coverage for these variables. For example, the calculation of the average of cereal yields is based on about 22 observations per country. The average cereal yield over the period 1980-2003 is 2129 kg per hectare. However, variation is high. In some countries the average yield is as little as 231 kg, whereas in the most productive countries the average yield is as high as 5877 kg.

Productivity enhancing equipment

To further analyze the channels through which financial sector development affects undernourishment, we assess the association of private credit with two productivity enhancing measures that require upfront outlays: fertilizer use (100 grams per hectare) and number of tractors per agricultural worker. Fertilizer use is on average 80 kg per hectare. However, this varies widely from 319 grams to 565.3 kg. The number of tractors per worker is on average 0.046, but again shows much dispersion, with the highest number per worker 0.55 and the lowest virtually 0.

Country controls

Following Beck, Demirgüç-Kunt, and Levine's (2005) study of the relationship between financial sector development and poverty, we use several country-level control variables which are likely to affect relationships. In all regressions using average values, we control for the initial value of the dependent variable, except for undernourishment, where we take the value of its first available observation in the period 1980-2003 (since we have an insufficient number of observations for undernourishment). Furthermore, we use as controls a range of variables including the log of initial government expenditures as a percentage of GDP (government size), the log of initial level of GDP per capita, in

2000 US$, corrected for purchasing power (economic development), the log of initial poverty, the average GDP deflator (average inflation), the log of the average fraction of the population in rural areas, the log of the average fraction of the population employed in the agricultural sector, and the log of the average value of trade (exports and imports) as a fraction of GDP.

We also take into account trade in food which may affect undernourishment and agricultural productivity. Specifically, in our panel regressions, we control for the yearly total food production per person in kilograms. We also control for the effects of international food trade, using the net food flow that leaves the country yearly, i.e., food export minus food import, expressed in kilograms per person. For both total food production and trade data, we use the data as provided by FAOSTAT of the Food and Agriculture Organization of the United Nations, averaged for the following time periods: 1979-81, 1990-92, 1993-95, 1995-97 and 2001-03. Finally, to investigate more general effects, we calculate a local producer price index based on yearly data from 1991-2001. The price index is the weighted-average price of the following main food categories: wheat, rice, maize, oats, barley, sheep meat, chicken meat, and pig meat. The price of each category is weighted by its share in total production of all categories in the particular country. The prices are in US dollars and corrected for "green" purchasing power parity. This PPP is calculated by FAO using a basket of agricultural products and related producer prices. To retain consistency, we make the periods for the price index as close as possible to the periods defined by the FAO. Specifically, we average the data over the following periods: 1991-92, 1993-95, 1995-97, and 2001.

Correlations

Panel B in Table 2 shows the correlations among the most important variables. All variables are significantly correlated with each other, with the expected sign. Importantly, the correlations show that higher levels of GDP per capita and private credit to GDP are associated with lower poverty and undernourishment and higher agricultural productivity and cereal yields. Panel C shows the correlations between our several agricultural productivity measures. All are positively correlated, but to different degrees, with the

correlation between overall agricultural productivity and cereal yields the highest. The two productivity indices, crop and livestock production, are also highly correlated with each other, but less with overall productivity and cereal yields. Panel D shows the high correlations among our productivity enhancing measures, as well as with overall agricultural productivity, with the number of tractors per worker the highest correlated with overall agricultural productivity.

B. Basic econometric model, instrumental variables, and fixed effects panel estimation

In our basic approach, we run cross-country OLS regressions for the period 1980-2003. To address endogeneity concerns, however, we also use an instrumental variables approach for this period. To further ameliorate endogeneity and omitted variable problems, we use a fixed effects panel estimation approach with five time periods: 1979-81, 1990-92, 1993-95, 1995-97, and 2001-03. We use these techniques for testing the relationships of interest, using four basic models to document the general relationship between financial sector development and undernourishment and the specific channels by which financial sector development reduces undernourishment (these relationships are also depicted in Panel A of Figure 1).

The first basic model investigates the general relationship between financial development and undernourishment:

$$undernourish_i = \alpha + \beta_1 FD_i + \mathrm{B}X_i + \varepsilon_i, \qquad (1)$$

where $undernourish_i$ is the average prevalence of undernourishment for country *i* of available data in the period 1980-2000, FD is private credit to GDP, and X_i is the vector of our control variables. If higher private credit to GDP indeed reduces undernourishment, we should find β_1 to be negative and economically and statistically significant.

We next analyze the channels. Before doing so, the second basic model analyzes the relationship between agricultural productivity and undernourishment:

$$undernourish_i = \alpha + \beta_1 productivity_i + BX_i + \varepsilon_i, \quad (2)$$

where $productivity_i$ is the average productivity per agricultural worker. If indeed higher productivity reduces undernourishment, we should find that β_1 is negative and economically and statistically significant.

This points us towards investigating the factors driving agricultural productivity.
The third basic model therefore scrutinizes the link between financial development and agricultural productivity:

$$productivity_i = \alpha + \beta_0 (ini\_productivity_i) + \beta_1 FD_i + BX_i + \varepsilon_i, \quad (3)$$

where $ini\_productivity_i$ is the first non-missing value of agricultural productivity in the period 1980-2003 to account for initial conditions. Our hypothesis predicts that β_1 is positive and economically and statistically significant, which would confirm that financial development increases productivity.

We then identify some specific channels as the fourth basic model scrutinizes the link between financial development and productivity enhancing inputs:

$$productivityenhancing_i = \alpha + \beta_0 (ini\_productivityenhancing_i) + \beta_1 FD_i + BX_i + \varepsilon_i, \quad (4)$$

where $ini\_productivityenhancing_i$ is the first non-missing value of agricultural productivity enhancing inputs in the period 1980-2003. We test specifically whether financial sector development relates to the use of productivity enhancing inputs, fertilizer and tractor use, to investigate the channels through which financial sector development may increase productivity. Our hypothesis predicts that β_1 is positive and economically and statistically significant, confirming that financial development increases the use of productivity enhancing inputs.

We amplify on these four models in more detailed analysis of the channels and robustness tests. Specifically, we expand model two by also relating cereal yield, a specific productivity measure, to undernourishment. And, we expand model three by relating financial sector development to other productivity measures, livestock production and crop and cereal yield.

The results in the basic four models could all be affected by endogeneity problems. At least in theory, in the first model, a reduction in undernourishment either directly or as a proxy for, say, a reduction in poverty, may stimulate demand for financial services, leading to reverse causality. In the second model, less undernourishment could translate into healthier, more productive workers, raising agricultural productivity. In the third model, higher productivity of workers could raise demand for financial services. And in the fourth model, use of productivity enhancing inputs can again lead to demand for financial services.

To alleviate these problems, we use an instrumental variables approach. We need two sets of instruments: one for private credit to GDP and one for agricultural productivity. To instrument for Private credit to GDP, we rely on the law and finance literature. This literature widely uses the legal origin of countries as an exogenous source of variation which is highly correlated with financial development measures, but not necessarily with undernourishment. This literature finds that property rights are better established in British common law countries and less so in Civil law countries (French, German, and Scandinavian origin) (see, for example, La Porta et al. 1997, 1998). These superior property rights facilitate financial contracting and translate into improved financial development. To instrument for agricultural productivity, we relay on fertilizer use in 100 grams per hectare of arable land and the number of tractors per agricultural worker. Arguably, these two variables are highly correlated with productivity but only indirectly with undernourishment.

We use two tests to validate our instruments: first we use the Hansen over-identifying restrictions test. This tests whether the instruments are associated with undernourishment

or agricultural productivity beyond their ability to explain cross-country variation in private credit to GDP. Under the null, the instruments are valid. We report the p-value of the test as “OIR test”. The second test assesses whether the instruments are able to explain cross-country differences in financial development or agricultural productivity. This test is provided as an F test in the first stage of the IV regressions. Under the null, the excluded instruments do not explain variation in the dependent variable. We report the p-values of the test as “F Test”.

Most importantly, to ameliorate further concerns about endogeneity problems and omitted variable bias we use fixed effects panel estimations whenever sufficient data are available. Some data are limited, however, and not always available annually. Specifically, most data from the FAO are only provided as averages for following five periods: 1979-81, 1990-92, 1993-95, 1995-97 and 2001-03. Consequently, we can not do panel regressions for the specific agricultural productivity indexes, cereal and crop yields.

IV. Empirical Results

To test the hypotheses that financial development reduces undernourishment specifically via an increase in agricultural productivity, we estimate the relationships of the four models: 1) between financial development and undernourishment directly, 2) between agricultural productivity and undernourishment, 3) between financial development and agricultural productivity, and 4) between financial development and agricultural productivity enhancing inputs (Panel A of Figure 1 shows these relationships).

A. Private credit and undernourishment

Table 3 shows our main result which strongly supports the basic hypothesis that financial development reduces undernourishment. Regression (1) presents the basic specification where undernourishment is the dependent variable and the main independent variable is private credit to GDP. In addition, we control for the initial levels of poverty and GDP per capita. Private credit enters negatively and significantly at the 5% level, with initial poverty and GDP per capita also very significant. The effect of financial sector development is economically very substantial. Since we use logs, the coefficient of -0.188 implies that a 1 percent increase in private credit to GDP reduces (the degree of) undernourishment by 0.188 percent.

Although we already use initial GDP per capita and poverty as controls, a concern could be that private credit correlates with other country factors and that this correlation drives our results. Hence, in Regression (2), we use additional country control variables: similar to Beck, Demirgüç-Kunt, and Levine (2004) we include initial size of government, inflation, trade as a percentage of GDP, rural population as a percentage of total population, and agricultural employment as a percentage of the workforce. Our result is not only robust to this inclusion in sign and significance, but the effects of financial sector development even increases in absolute magnitude. Figure 2 depicts this relationship. To ensure our results are not driven by richer countries, in Regression (3) we next drop countries with above median GDP per capita for the whole sample from the analysis (GDP per capita <$4671). The result becomes even more significant and

increases further in absolute magnitude, suggesting that the effect of financial sector development on undernourishment is primarily driven by poorer countries.

Next, we want to alleviate endogeneity concerns. In theory, it is possible that lower levels of undernourishment increases demand for financial services. Therefore following the law and finance literature, we use in Regressions (4) and (5) the same specification as in regressions (1) and (2), but now employ an instrumental variable (IV) estimation approach, where we instrument private credit to GDP with legal origin. Legal origin has been shown to determine the quality of property rights, and in turn, better property rights have been shown to enable higher financial development. Our tests indicate that the instruments are valid. The regressions show that private credit remains significant and even increases in absolute magnitude, the largest coefficient becoming -2.448.

To further control for possible endogeneity, we next conduct in Regression (6) a panel estimation using country fixed effects, where we use up to five observations on undernourishment in an unbalanced panel using five periods: 1979-81, 1990-92, 1993-95, 1995-97, and 2001-03. We continue to use the same control variables, but include now also initial food production per capita. In Regression (6), we do not include poverty and GDP per capita because the fixed effects already absorb the average level of poverty and income. We find our main result of the importance of financial sector development to be confirmed, with private credit having a negative effect on undernourishment. Lastly, Regression (7) shows that when we include GDP per capita in each of the five periods, the coefficient of private credit remain significant, albeit at the 10% level. This shows that there is an effect of financial sector development on undernourishment independent of general development. Even when we also include government size, private credit is still marginally significant in the panel regression (p-value: 0.107; not reported).

B. Agricultural productivity and undernourishment

So far we have shown the strong and robust effects of financial sector development on undernourishment. We next want to investigate the channels from financial development to undernourishment by focusing on how financial sector development affects an

intermediate outcome: agricultural productivity, where agricultural productivity in turn affects undernourishment. But before looking at the effects of financial sector development on agricultural productivity, we need to show that agricultural productivity leads to lower undernourishment. We do this both at the aggregate level investigating the effects of agricultural output per worker on undernourishment, and through investigating the effects of more specific forms of agricultural productivity, such as cereal yields, on undernourishment. In the next section, we then show that financial development leads to higher agricultural productivity.

Table 4 shows the results. Regression (1) confirms that agricultural productivity decreases undernourishment, even after controlling for the initial levels of poverty and GDP per capita. The effect is economically large: our finding suggests that a 1 percent increase in agricultural productivity decreases undernourishment with 0.244 percent. To ameliorate omitted variable bias, we include our standard country controls. This strengthens our basic finding in terms of significance (at the 1% level) and magnitude (it almost doubles to -0.407). Figure 3 depicts this relationship. To ensure again that the result is not driven by richer countries, we focus in Regression (3) on the poorest countries (with GDP per capita <$4671, the median of the total sample). We find that productivity is still significant at the 1% level and increases further in absolute magnitude.

We would like to know whether private credit to GDP affects undernourishment through agricultural productivity or whether there is a (stronger) other channel. Hence, in Regression (4) we include private credit to GDP in the regression. We find that financial sector development is not significant, but agricultural productivity still is. This suggests that productivity is an important channel by which private credit reduces undernourishment.[5] We next address possible endogeneity problems in our regressions by instrumenting agricultural productivity by fertilizer use and number of tractors per agricultural worker. Regressions (5) and (6), with the latter using more control variables,

[5] When we also include initial GDP per capita in the regression, both private credit and productivity are not significant anymore (p-values around 0.12), indicating that the effects of both on undernourishment are absorbed in the effect of GDP per capita on undernourishment (not reported).

both show significant effects (at least at the 5% level) of productivity on undernourishment. The coefficients actually show a substantial increase in absolute magnitude, with coefficients of about -0.8. Our tests indicate again that the instruments are valid. Our last and most comprehensive test for simultaneity and missing variables affecting the result is a panel estimation using fixed effects (and controlling for clustering at the country level). Regression (7) shows that the results are maintained, with a strong negative impact of productivity on undernourishment, with the coefficient similar in magnitude to the basic regression.

We next study whether a more detailed measure of agricultural productivity, cereal yields, confirms the general results of higher agricultural productivity leading to lower undernourishment. Table 5, following the same structure as Table 4, presents the results. Regression (1) shows that cereal yields indeed seems to significantly (at the 5% level) reduce undernourishment, even after controlling for initial levels of poverty and GDP per capita. The coefficient implies that a 1 percent increase in cereal yields decreases undernourishment by 0.27 percent. In Regression (2) we add country controls to ameliorate omitted variable bias. The coefficient becomes marginally larger in magnitude and stays significant at the 5% level. Regression (3) exclude countries with above median GDP per capita, and shows the result is not driven primarily by rich countries: the coefficient increases in magnitude, although it becomes marginally significant. Regression (4) shows that private credit is not significant, but cereal yields still is. This suggests that productivity is an important channel by which private credit reduces undernourishment.

Regression results (5) and (6) show that our results not likely suffer from endogeneity problems since when we instrument cereal yields with fertilizer use and tractors per worker, the coefficients for undernourishment remain statistically significant. The magnitudes of the coefficients again further increase to over 0.45 and are significant at the 1% level. Tests show that our instruments are valid. Next we run an unbalanced panel regression for 106 countries and 5 periods with on average 2.5 observations per country, using fixed effects (and controlling for clustering at the country level). The results

reconfirm that cereal yields greatly explains undernourishment and further ameliorates concerns over endogeneity and omitted variables driving our results. Overall, the results of Table 5 confirm the more general results of Table 4 that agricultural productivity reduces undernourishment. The question we turn to next is whether financial sector development drives agricultural productivity.

C. Private credit and agricultural productivity

After establishing a causal effect from agricultural productivity to undernourishment, we next study the link between private credit and agricultural productivity. Table 6 shows our results when we use an aggregate measure of agricultural productivity. Regression (1) displays the basic analysis, where besides initial GDP per capita and poverty, we control for the initial level of agricultural productivity. We find a highly significant effect of private credit on agricultural productivity. The coefficient implies that a 1 percent increase in private credit increases productivity by 0.128 percent. Note that private credit and initial productivity combined absorb the effect of GDP per capita as that variable is no longer significant. Regression (2) confirms our result after including other country variables as the coefficient remains significant at the 1% level and the magnitude increases slightly to 0.144. Figure 4 depicts this relationship. To ensure our results are not driven by richer countries, in Regression (3) we again drop countries with above median GDP per capita (>$4,671) of the whole sample and still find a highly significant result, with the magnitude not changed.

Next, we address endogeneity concerns by using an IV approach. As in the previous analyses, we instrument private credit with legal origin. Regressions (4) and (5) confirm our basic result at the 5% significance level. Note that the size of the effect increases dramatically to 1.679 for regression (5). However, for this regression, the F test raises some concern of the validity of the instruments. As another test for endogeneity, we conduct the panel regression, Regression (6), and find that there remains a very strong effect of private credit on agricultural productivity.

As a robustness check, we next analyze the impact of private credit on agricultural productivity *growth*. Growth is calculated by subtracting the logs of the last and the first available observation in the period 1980-2003 and dividing by the time span between these two observations. Regression (7), where we re-run the IV specification of regression (5), shows that importance of financial sector development for growth in agricultural productivity is confirmed as the coefficient on private credit is statistically significant and positive. The result is again economically significant. A 1 percent increase in private credit leads to a 0.5 percent growth increase. Although the F-test casts some doubt on the validity of the instruments, the F-test is fine when we do not include the country controls (but do control for initial productivity, GDP per capita, and poverty, like in equation (2)). The coefficient in that case is 0.070 (not reported), and hence still quite large.

D. Specific channels

Having established a causal relationship between private credit and general agricultural productivity, we next ask whether specific agricultural outputs are also affected by private credit. Therefore, we consecutively analyze the effect of private credit on cereal yields per hectare of arable land, cereal yields growth, and growth in livestock production, and crop production. Table 7 presents the results. Regressions (1) and (2) show that private credit is associated (at the 1% level) with higher cereal yields. This finding indicates that financial development drives agricultural productivity to a substantial extent via an increase in cereal yield. The economic effect is not small. The result indicates that a 1 percent increase in private credit increases cereal yields by 0.08 percent. Regression (2) adds country controls, without affecting the result; the impact of private credit increases marginally in magnitude and stays significant at the 1% level. The result is also robust to dropping countries which have above median GDP per capita from the sample, Regression (3). The impact increases to 0.110 and stays highly significant. To address endogeneity concerns, we again instrument private credit with legal origin. Now the magnitude increases dramatically to 1.682 and private credit is now only marginally significant. Tests confirm the validity of the instruments. These findings, however, are not robust to inclusion of all country controls (not reported): in that case, although the

coefficient of private credit increases even to 1.94, it is no longer significant (p-value: 0.135).

As another robustness check, we analyze the impact of private credit on the *growth* rate of cereal yields. Regression (5) shows that at the 5% level, a 1 percent increase in private credit is associated with a 0.003% additional growth in cereal yields. Note that the coefficients for private credit in the cereal yields regressions are generally lower than in Table 6, where we analyzed its impact on overall agricultural productivity. This suggests that the effect of financial sector development on increase in cereal yields is perhaps important, but not the only means by which financial sector development drives the increase in agricultural productivity.

We next investigate the association with the growth in livestock production and crop production. Since both indices, by construction, have a value of 100 in 1999-2001, we use the initial values for the indexes as the dependent variables, meaning that if the initial value was low, growth over the next years was high for that country. Consequently, we would expect a negative sign for private credit if that spurs production. We indeed find this result of private credit for both the livestock and crop production indexes, and very significant as well (at the 1% level). This shows that financial sector development leads to high productivity growth in crops and livestock.

E. Private credit and productivity enhancing inputs

We have shown that financial development indeed spurs agricultural productivity. We next want to investigate the channels. We expect that financial development to be associated with an increase in the use of productivity enhancing inputs that require some upfront financing or outlays. This would provide further evidence of the specific channels of financial sector development on undernourishment. We are constrained in the data we have for a large set of countries. Therefore, we use data on fertilizer use and the number of tractors per agricultural worker, inputs which require upfront outlays. When we assess the impact of private credit, Regression (1) in Table 8 shows that private credit is significantly (at the 1% level) associated with fertilizer use, even after controlling for the

initial level of fertilizer use, GDP per capita, and poverty. The result implies that a 1 percent increase in private credit increase fertilizer use by 0.44 percent. To address a potential endogeneity problem, we instrument in Regression (2) private credit with legal origin. Although the magnitude of the effect increases substantially (to 1.6), the result is no longer significant. Moreover, econometrically the tests cast doubt on the validity of the instruments. However, if we do *not* control for the initial level of fertilizer use, the coefficient increases to 4.58 and is significant at the 5% level (not reported). In addition, tests show that the instruments are then valid (F Test: 0.003; OIR Test: 0.50). In Regression (3) we run a panel regression and find no significant impact of private credit on fertilizer use.

Next, we assess the impact of financial sector development on the use of tractors per worker. Regression (4) shows a significant impact (at the 1% level), after controlling for the initial levels of tractors per worker, GDP per capita, and poverty. The result implies that a 1 percent increase in private credit increases tractor use by 0.244 percent. When we instrument in Regression (5) private credit with legal origin, the effect remains significant at the 1% level, but increases dramatically in size. Here the coefficient implies that a 1 percent increase in private credit leads to a 5.5 percent increase in the number of tractors per worker. Tests indicate that our instruments remain valid. We next run a panel Regression (5) for tractors per worker and find a significant impact of private credit, with a coefficient of 0.140. Together, these findings further confirm an important role of private credit in increasing the use of productivity enhancing inputs.

As a robustness check on the channels, we analyze the direct impact of financial sector development on the prices of foods. One channel by which financial sector development may help reduce undernourishment is to lead to a greater supply of food products, lowering their prices and thereby making food more available to poor households, and thus reducing undernourishment. We have many individual food prices and create a rough price index for the following basket of foods: barley, rice, oats, wheat, maize, pig meat, chicken meat, and sheep meat. In constructing this index, we weight the price of every food with its produced quantity as a fraction of total production of all these foods.

All prices are expressed in dollars and take into account an agricultural version of purchasing power parity. When we run a panel regression of this food price index, controlling for the usual country-level characteristics (like in Regression 3) we find no statistically significant effect of private credit on prices. While we do not want to give too much emphasis to this result, it nevertheless suggests that a reduction in prices is not the main channel by which financial sector development reduces undernourishment. This implies that finance is important more directly. We will turn to next to the importance of access to financial services for reducing undernourishment.

F. The role of access to financial services for the impact of finance on undernourishment

So far, we have used a very aggregate measure of financial sector development, private sector to GDP, and associated increases in that measure with greater access to financial services. But access to financial services may be unequal across households and it may not be the poor or undernourished that benefit from greater financial sector development. Unfortunately, there are little data on access to financial services by individual households or small firms across a large set of countries and covering any consistent time span (see Honohan, 2005 and 2006 for what data are available and data deficiencies). What we do have are measures of the number of access points to the formal financial system, specifically the number of branches and ATMs for the year 2003-2004. These distribution data can be useful proxies for access. Burgess and Pande (2005), for example, show the importance of the banking system distribution in case of India. We use these data, scaled by the size of the country in square kilometers, in our cross-section regressions to distill the joint impact of financial sector development and access to financial services on undernourishment, productivity, productivity enhancing inputs and prices. We control in these regressions for the degree of country openness, the size of government, and the degree of inflation, as well as food production per capita and food net exports in the price regression. The results are reported in Table 9.

We find that there is a beneficial effect of the reach of the financial system on undernourishment (Regression 1). The effect of financial reach is actually so strong as to make the coefficient for private credit no longer statistically significant. The effects of

reach are also strong for agricultural productivity (Regression 2). Here, there remains a direct and highly statistically significant effect of private credit on productivity, consistent with the earlier regression results. Differentiating productivity somewhat further, we find that both reach and private credit are statistically significant in explaining cereal yields (Regression 3). In terms of productivity enhancing inputs, we find that reach matters for tractors and fertilizers usage, but that private credit is no longer statistically significant for tractors (Regression (4 and 5). Finally, we find that there is a negative effect of outreach on the price of food, suggesting that greater access to financial services indirectly can make food more affordable for the poor. The effect of financial sector development itself on food prices is again positive. All in all, while mostly suggestive as we lack good data on access, these regression results point to the importance of reach of a financial system for reducing undernourishment.

G. Comparing the impact of private credit and GDP per capita on undernourishment

We have shown that private credit significantly reduces undernourishment, but is the impact relatively large? In this section, we show that private credit has about one-quarter of the impact of GDP per capita on undernourishment. That is large, given that private credit also increases GDP per capita itself substantially.

We gauge the relevance of private credit by comparing the effect of private credit on undernourishment and GDP per capita on undernourishment. Similar to Besley and Burgess (2003), we ask the question: what is the reduction in undernourishment in 9 years (by 2015, the deadline for the MDGs) caused by increases in private credit and in GDP per capita, respectively, if both variables follow their historical average country growth rates.

In our sample, the average country GDP per capita growth was 1.198%; the average country private credit growth was 1.059%. We also need the elasticities of private credit to GDP per capita. The elasticity of undernourishment to GDP per capita is -0.8494 (based on a simple regression with only GDP per capita as an explanatory variable; not

reported). The elasticity of private credit to undernourishment from a basic OLS regression is -0.224 (see Regression (2), Table 3).

Based on these elasticities we calculate that in 9 years, using historical growth rates, increases in GDP per capita would reduce undernourishment by about 8.70%. Historical growth rates for private credit to GDP growth would reduce undernourishment by about 2.10%.[6] Hence, the effect of private credit on undernourishment is substantial, about on-quarter that of GDP per capita.

H. Illustrative analysis of a private credit increase on undernourishment via several channels

The previous section showed that the impact of private credit on undernourishment is relatively large. But via which channels does private credit deliver its largest impact on undernourishment? To explore this, we calculate the impact of a 1 percent increase in private credit via the several channels we have identified on undernourishment. This allows us to assess to which extent these channels account for the effect on undernourishment, in relation to the overall effect we have found from private credit to undernourishment. We study three channels from private credit to undernourishment: 1) via productivity, 2) via productivity enhancing inputs (fertilizer use and number of tractors per worker), and 3) via cereal yield. These more specific channels are depicted in Panel B of Figure 1.

Table 10 presents the findings. In calculating these magnitudes, we use two types of coefficient estimates from our analyses. The first (column 2) are the coefficients taken from OLS regressions which contain all control variables. The second (column 4) are the coefficients taken from IV regressions which also contain all control variables. By construction, we set the percentage of the aggregate channel between private to GDP and undernourishment (the relationship depicted in Figure 2) at 100% (coefficient OLS: -0.224; coefficient IV: -2.488). And as our comparison, we use the coefficient for GDP

[6] EXP(-0.8494*9*LN(1.01198))-1 and EXP(-0.224*9*LN(1.010589))-1, respectively.

per capita in an OLS regression explaining undernourishment, which is -0.849 (not reported).

First, we analyze the impact of a 1 percent increase in private credit via the productivity channel on undernourishment (the relationship depicted in Figure 3). The OLS impact is: -0.059 or 26.2% of the magnitude of the aggregate effect of private credit on undernourishment. This finding implies that besides a large role for the productivity aspect of financial development, there are also other aspects, including the consumption smoothing and transaction facilitating roles of finance. The IV effect is -.1347 or 55% of the magnitude of the aggregate effect.

As a next refining step, we analyze the effect of a 1 percent increase in private credit via productivity on undernourishment (the relationship depicted in Figure 4). For this we regress fertilizer use and the number of tractors per worker on agricultural productivity, while controlling for private credit and initial GDP per capita. Both fertilizer use and number of tractors per worker are at least significant at the 5% level with coefficients of 0.107 and 0.159, respectively (not reported). From this, we calculate the joint impact to be -0.035 or 15.6% of the aggregate impact of private credit on undernourishment and 59.7% of the impact of private credit on undernourishment via productivity. This finding implies a large residual role for private credit in other productivity enhancing roles, besides an increase in fertilizer use and number of tractors per worker. In addition to the consumption smoothing, transaction facilitating and insurance roles of finance, one possible alternative is the financing of ancillary private and public agricultural services, such as warehouses, processing facilities, ports and roads. Another possibility is higher productivity of the workers due to increased education. Financial less dependent farmers may, for example, be more likely to enter educational programs on agricultural productivity. Education may also accompany the use of financial services. In Bangladesh, for example, microcredit programs contain educational aspects (see Littlefield, Morduch and Hashemi, 2003 for other examples).

Lastly, we find that cereal yields contribute significantly to lower undernourishment when we calculate the effect of a 1 percent increase in private credit via cereal yields on undernourishment. The OLS impact is -0.026 or 11.7% of the direct effect of private credit. The IV impact is -0.816 or 33.3% of the direct effect of private credit. This result suggests that increases in cereal yields play an important role in reducing undernourishment, since they both represent 44.6% and 60.8% of the impact of productivity directly, respectively.

V. Conclusions

This paper shows that financial sector development can play a significant role in reducing undernourishment. First, we find that private credit leads to lower undernourishment. Second, we find that greater agricultural productivity and cereal yields lead to a reduction in undernourishment. Third, in terms of channels, we show that private credit leads to higher agricultural productivity in general and higher live stock, crop and cereal yields in particular. Fourth, to a large extent, this increased productivity as a result of greater financial sector development can be explained by an increase in fertilizer use per hectare and more tractors per worker. Fifth, we find limited evidence of general equilibrium effect of financial sector development on undernourishment through reduced food prices. Lastly, our results suggest that to reduce undernourishment through these channels it is not only important to have a well developed financial system, but also to ensure good distribution of outlets. These results are robust to the inclusion of country controls, several samples, and instrumental variables.

Our findings are consistent with the hypothesis that access to credit allows agricultural workers to finance productivity enhancing equipment like fertilizers and tractors. Even when direct access to financial services is limited for undernourished households, they can still benefit from financial development because they interact with suppliers and others that have access to financial services. More generally, the undernourished can benefit from financial sector development because an increase in agricultural productivity leads to an increase in food output.

These effects are also quantitatively important. Assuming, for example, that private credit and GDP per capita follow their historical country average growth rates, our result imply that that the impact of private credit on undernourishment is about one-quarter of the impact of GDP per capita by the year 2015. Using the data, we can also show through which channels an increase in private credit delivers its largest impact on undernourishment and compare the effects of private credit on undernourishment with that of GDP per capita on undernourishment. We can report three relative magnitudes: first, productivity is an important channel and accounts for 26%-55% of the impact of private credit on undernourishment. The remainder could be explained by for example the consumption smoothing functions of financial services. Second, we find that the private credit's increase in productivity enhancing equipment like fertilizer and tractors is important. We find that 60%-63% of the impact of private credit via productivity is accounted for by an increase in fertilizer use and the number of tractors per worker. Factors like education could play a large role to explain the remainder of the impact of productivity. Third, 45%-61% of the productivity impact can be accounted for by an increase in cereal yields. This finding suggests that increasing cereals production is an important source of decreasing undernourishment.

Taken together, our findings imply that financial sector development can contribute substantially to attaining the most important Millennium Development Goal: alleviation of extreme poverty. Policies which could foster financial sector development with wide access are multiple and include: ensuring a stable macroeconomic environment, enhancing financial sector regulation and enforcement, creating a proper credit information institutional infrastructure, and enforcing property rights. The importance of these policies for financial sector development has been well-documented in other research, but our findings give more impetus to furthering financial sector development, especially when it gives access to financial services for a broad class of people. It also gives impetus to more research on finding ways in which financial sector development can specifically help with increased agricultural productivity, as that appears to be an important channel for reducing undernourishment.

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Table 1. Description of Variables

This table presents the variables used in our regression analysis and their description. The sources are WDI (World Development Indicators (2005), FAO (Website of Food and Agriculture Organization of the United Nations (2006)), and Beck (Beck, Demirgüç-Kunt, and Martinez Peria, forthcoming).

Variable	Description	Source
MAIN VARIABLES:		
Undernourishment	Log prevalence of undernourishment as a percentage of the total population, averaged over the period 1980-2003 for which we have observations. For most countries three observations are available for three periods: 1991-1993, 1994-1996, 1997-1999.	WDI
Private credit to GDP	Log value of credit by financial intermediaries to the private sector as a percentage of GDP averaged over the period 1980-2003 for which we have observations.	WDI
Agricultural productivity	Log yearly productivity per agricultural worker, expressed in constant 2000 US Dollars, corrected for purchasing power averaged over the period 1980-2003 for which we have observations.	WDI
Branches per 1,000 km^2	Number of banking branches per 1,000 km^2	Beck
PRODUCTIVITY MEASURES:		
Cereal yield	Log cereal yields per hectare of arable yield in kilograms averaged over the period 1980-2003 for which we have observations.	WDI
Crop production index	Log prop production index (1999-2001=100) averaged over the period 1980-2003 for which we have observations.	WDI
Livestock production index	Log livestock production index (1999-2001=100) averaged over the period 1980-2003 for which we have observations.	WDI
PRODUCTIVITY ENHANCING EQUIPMENT:		
Fertilizer use	Fertilizer use in 100 grams per hectare	WDI
Tractors per worker	Number of tractors per agricultural worker	WDI
COUNTRY CONTROLS:		
Poverty	Log of average percentage of the population living on less than 1$ per day (in 1983 US$, corrected for purchasing power) in the period 1980-2003 for which we have observations.	WDI
Initial poverty	Log of the first available observation in the period 1980-2003 of the percentage of the population living on less than 1$ per day (in 1983 US$, corrected for purchasing power).	WDI
Initial GDP per capita	Log of the first available observation in the period 1980-2003 of GDP per capita in 2000 US$, corrected for purchasing power.	WDI
Initial size government	Log of the first available observation in the period 1980-2003 of government expenditures as a percentage of GDP.	WDI
Inflation	The average of the GDP deflator in the period 1980-2003 for which we have observations.	WDI
Trade	Log of average trade as a percentage of GDP in the period 1980-2003 for which we have observations.	WDI
Price index	The log of average prices of barley, oats, rice, maize, wheat, pig, chicken, and sheep meat, weighted by their produced quantities as a fraction of total production of these foods. Local producer prices for selected agricultural products are converted to dollars first at prevailing exchange rates and then with a "green" purchasing power parity (PPP). This PPP is calculated by FAO using a basket of agricultural products and related producer prices.	FAO
Food production	The log of total food production in kg per person per year. Production pertains to Alcohol (incl. beer and wine), Animal fats and products, Aquatic products, other Beverage crops, Cereals and prod. Excl. beer Eggs and products Fish, seafood and prod. Fruits and prod. (excl. wine) Meat (slaughtered) and prod.	FAO

	Milk and products, Offals edible, Oilcrops (excl. prod.), Pulses and products, Spices, Starchy roots and products, Sugar and Sweeteners, Treenuts and products Vegetable oils and prod., Vegetables and products	
Export -/- Import	Total food export minus total food import in kg per person per year. The variable pertains to the same food groups as Food production.	FAO
Rural population	Log of average percentage of population in rural areas in the period 1980-2003 for which we have observations.	WDI
Agricultural employment	Log of average percentage of agricultural workers in the workforce in the period 1980-2003 for which we have observations.	WDI

Table 2. Descriptive Statistics

Panel A presents standard descriptive statistics for undernourishment, private credit and agricultural productivity for the observations in the basic regression of the main result, Regression (2) of Table 3 (except for banking branches per 1,000 km^2, which pertains to either 2003 or 2004). Average number is the average number of observations with which the average in the period 1980-2003 has been calculated. Tables B, C, and D display correlations and p-values pertaining to the main variables, productivity measures, and productivity enhancing equipment, respectively. Correlations are based on the whole sample.

Panel A: Summary statistics

Average value in period 1980-2003 of:	Countries	Mean	Std. Dev.	Min	Max	Average number of observations used
Undernourishment	86	18.72	14.46	2.5	57	2.73
Private credit	86	26.51	20.47	2.8755	112.17	19.62
Agricultural productivity	85	1802.47	2658.80	111.66	21114.54	20.39
Cereal yield	85	2129.82	1170.24	231.20	5877.61	22.17
Fertilizer use	85	5.74	1.61	1.16	8.64	19.83
Tractors per worker	84	0.05	0.09	0.00	0.55	20.07
Branches per 1,000 km^2 (2003-2004)	91	31.03	82.11	0.11	636.07	1

Panel B: Correlations of main variables

	GDP/cap.	Poverty	Under nourishment	Productivity	Cereal yield
Poverty	-0.77				
	0.00				
Under	-0.75	0.77			
nourishment	0.00	0.00			
Agricultural	0.91	-0.76	-0.75		
productivity	0.00	0.00	0.00		
Cereal	0.65	-0.53	-0.52	0.66	
Yield	0.00	0.00	0.00	0.00	
Private	0.71	-0.33	-0.30	0.55	0.40
credit	0.00	0.00	0.00	0.00	0.00

Panel C: Correlations of productivity measures

	Agric. productivity	Cereal yield	Livestock
Cereal yield	0.66		
	0.00		
Livestock	0.27	0.15	
	0.00	0.05	
Crop	0.32	0.20	0.63
	0.00	0.01	0.00

Panel D: Correlations of productivity enhancing equipment

	Fertilizer use	Tractors per worker
Tractors per	0.58	
Worker	0.00	
Agricultural	0.66	0.83
productivity	0.00	0.00

Table 3. Impact of Private Credit on Undernourishment

This table reports OLS estimations in Regressions (1)-(3), and 2SLS estimations in Regressions (5) and (6) for the period 1980-2003. Regression (6) reports panel fixed effects estimations for the 1990s. All variables are in logs, except inflation. The dependent variable is the log average prevalence of undernourishment (percent). The main independent variable is average private credit to GDP (percent). Other independent variables are the initial levels of GDP per capita, poverty, and government expenditure as a percentage of GDP in the period 1980-2003. Other controls are average inflation, average poverty, percentage trade of GDP, the percentage of the population living in rural areas, and the percentage of the workforce in agriculture. The 2SLS estimations use legal origin dummies indicating English, French, German, and Scandinavian law as instruments for private credit per GDP. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. Regression (6) is a panel fixed effects regression with on average 2.5 observations per country. Additional control variables are food production per person (kg) food export -/- food import per person (kg). Standard errors are corrected for clustering at the country-level. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Average prevalence of undernourishment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Basic	Controls	Controls; poorest 50%	IV: Basic	IV: Controls	Panel: Fixed effects	Panel: FE; Control for GDP/cap.
Private credit	-0.188	-0.224	-0.313	-1.567	-2.448	-0.066	-0.060
	(0.088)**	(0.101)**	(0.107)***	(0.434)***	(1.313)*	(0.034)*	(0.034)*
Initial Poverty	0.384	0.385	0.211	0.152	-0.021		
	(0.066)***	(0.072)***	(0.076)***	(0.207)	(0.358)		
(Initial) GDP/cap.	-0.279	-0.282	-0.202	0.252	0.401		-0.130
	(0.105)***	(0.148)*	(0.162)	(0.284)	(0.515)		(0.089)
(Initial) size Government		-0.198	-0.189		-0.338	0.066	
		(0.162)	(0.198)		(0.556)	(0.054)	
Inflation		-0.000	-0.000		-0.000	-0.040	-0.034
		(0.000)*	(0.000)***		(0.000)*	(0.016)**	(0.016)**
Trade		0.349	0.088		0.921	-0.072	-0.096
		(0.164)**	(0.205)		(0.647)	(0.081)	(0.090)
Rural Population		-0.061	-0.733		-0.328		
		(0.246)	(0.523)		(0.720)		
Agricultural Employment		0.087	0.247		0.188		
		(0.129)	(0.136)*		(0.283)		
Food Production						-0.995	-0.761
						(0.121)***	(0.137)***
Export -/- Import						0.001	0.000
						(0.000)***	(0.000)
Observations	95	86	52	56	49	253	253
Countries						103	103
OIR Test				0.59	0.82		
F Test				0.000***	0.000***		
R-squared	0.61	0.65	0.57			0.52	0.37

Table 4. Impact of Agricultural Productivity on Undernourishment

This table reports OLS estimations in Regressions (1)-(5) and 2SLS estimations in Regression (6) and (7) for the period 1980-2003. Regression (8) reports panel fixed effects estimations for the 1990s. All variables are in logs, except inflation. The dependent variable is the log average prevalence of undernourishment (percent). The main independent variable is average productivity per agricultural worker in constant 2000 US$. Other independent variables are the initial levels of GDP per capita, poverty, and government expenditure as a percentage of GDP in the period 1980-2003. Other controls are average inflation, average poverty, percentage trade of GDP, the percentage of the population living in rural areas, and the percentage of the workforce in agriculture. The 2SLS estimations use number of tractors per agricultural worker and fertilizer use (100 grams per arable hectare) as instruments for productivity per agricultural worker. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. Regression (8) is a panel fixed effects regression with on average 2.5 observations per country. An additional control variable is food export -/- food import per person (kg). Standard errors are corrected for clustering at the country-level. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Average prevalence of undernourishment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Basic	Controls	Controls; poorest 50%	Private credit	IV: Basic	IV: Controls	Panel: Fixed effects
Agricultural Productivity	-0.244	-0.407	-0.526	-0.231	-0.790	-0.802	-0.381
	(0.126)*	(0.088)***	(0.132)***	(0.111)**	(0.254)***	(0.313)**	(0.114)***
Initial Poverty	0.311			0.358	0.213	0.232	
	(0.069)***			(0.070)***	(0.086)**	(0.093)**	
Initial GDP/cap.	-0.134	-0.267	0.127		0.380	0.119	
	(0.172)	(0.117)**	(0.146)		(0.259)	(0.213)	
Private Credit				-0.194			
				(0.101)*			
(Initial) size Government		-0.184	-0.201	-0.228		-0.296	-0.033
		(0.165)	(0.160)	(0.176)		(0.228)	(0.070)
Inflation		-0.000	-0.000	-0.000		-0.000	-0.026
		(0.000)**	(0.000)***	(0.000)*		(0.000)*	(0.016)
Trade		0.235	0.107	0.341		0.467	-0.133
		(0.163)	(0.151)	(0.153)**		(0.200)**	(0.119)
Rural Population		-0.009	-0.654	-0.049		-0.536	
		(0.228)	(0.381)*	(0.261)		(0.433)	
Agricultural Employment		0.097	0.263	0.067		0.005	
		(0.096)	(0.101)**	(0.119)		(0.102)	
Export -/- Import							-0.000
							(0.000)
Observations	95	101	64	85	94	85	254
Countries							103
OIR Test					0.97	0.47	
F Test					0.000***	0.000***	
R-squared	0.60	0.59	0.55	0.65			0.21

Table 5. Specific Channel to Productivity: Impact of Cereal Yields on Undernourishment

This table reports OLS estimations in Regressions (1)-(4) and a 2SLS estimation in Regressions (5) and (6) for the period 1980-2003. Regression (7) reports panel fixed effects estimations for the 1990s. All variables are in logs, except inflation. The dependent variable is the log average prevalence of undernourishment (percent). The main independent variable is cereal yields (kg per hectare). Other independent variables are the initial levels of GDP per capita, poverty, and government expenditure as a percentage of GDP in the period 1980-2003. Other controls are average inflation, average poverty, private credit to GDP, percentage trade of GDP, the percentage of the population living in rural areas, and the percentage of the workforce in agriculture. The 2SLS estimations use number of tractors per agricultural worker and fertilizer use (100 grams per arable hectare) as instruments for productivity per agricultural worker. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. Regression (7) is a panel fixed effects regression with on average 2.5 observations per country. Additional control variables are food production per person (kg) food export -/- food import per person (kg). Standard errors are corrected for clustering at the country-level. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Average prevalence of undernourishment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Basic	Controls	Controls; poorest 50%	Private credit	IV: Basic	IV: Controls	Panel: Fixed effects
Cereal Yield	-0.269	-0.297	-0.384	-0.243	-0.452	-0.485	-0.160
	(0.112)**	(0.128)**	(0.214)*	(0.128)*	(0.150)***	(0.162)***	(0.079)**
Initial Poverty	0.312	0.300	0.122	0.344	0.283	0.268	
	(0.065)***	(0.076)***	(0.069)*	(0.075)***	(0.065)***	(0.073)***	
Initial GDP/cap.	-0.345	-0.329	-0.192	-0.280	-0.322	-0.316	
	(0.084)***	(0.129)**	(0.185)	(0.133)**	(0.081)***	(0.125)**	
Private credit				-0.176			
				(0.106)			
(Initial) size Government		-0.288	-0.343	-0.299		-0.355	0.019
		(0.184)	(0.208)	(0.183)		(0.180)**	(0.055)
Inflation		-0.000	-0.000	-0.000		-0.000	-0.029
		(0.000)	(0.000)*	(0.000)		(0.000)	(0.017)*
Trade		0.299	0.108	0.345		0.296	-0.063
		(0.170)*	(0.181)	(0.165)**		(0.165)*	(0.087)
Rural Population		-0.059	-0.582	-0.106		-0.083	
		(0.260)	(0.647)	(0.249)		(0.266)	
Agricultural Employment		0.131	0.331	0.103		0.134	
		(0.122)	(0.123)**	(0.131)		(0.118)	
Food Production							-0.933
							(0.141)***
Export -/- Import							0.001
							(0.000)***
Observations	95	86	53	85	94	85	257
Countries							106
OIR Test					0.39	0.42	
F Test					0.000***	0.000***	
R-squared	0.60	0.64	0.54	0.66			0.52

Table 6. Impact of Private Credit on Agricultural Productivity

This table reports OLS estimations in Regressions (1)-(3), and 2SLS estimations in Regressions (4), (5), and (7) for the period 1980-2003. Regression (6) reports panel fixed effects estimations for the 1990s. All variables are in logs, except inflation. In Regressions (1)-(5), the dependent variable is the log average agricultural productivity per worker in constant 2000 US$. In Regression (6) and (7) the dependent variable is the growth in agricultural productivity per worker in the period 1980-2003. The main independent variable is private credit to GDP (percent). Other independent variables are the initial levels of GDP per capita, poverty, and government expenditure as a percentage of GDP in the period 1980-2003. Other controls are average inflation, average poverty, percentage trade of GDP, the percentage of the population living in rural areas, and the percentage of the workforce in agriculture. The 2SLS estimations use legal origin dummies indicating English, French, German, and Scandinavian law as instruments for private credit per GDP. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. Regression (6) is a panel fixed effects regression with on average 2.5 observations per country. An additional control variable is food export -/- food import per person (kg). Standard errors are corrected for clustering at the country-level. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Average agricultural productivity						Agric. Prod. growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Basic	Controls	Controls; poorest 50%	IV: Basic	IV: Controls	Panel: Fixed effects	IV: Controls
Private Credit	0.128 (0.028)***	0.144 (0.030)***	0.140 (0.033)***	1.195 (0.467)**	1.679 (0.816)**	0.094 (0.032)***	0.095 (0.045)**
Initial Productivity	1.022 (0.037)***	1.032 (0.052)***	1.058 (0.059)***	1.165 (0.171)***	1.406 (0.364)***		0.024 (0.020)
Initial GDP/cap.	-0.050 (0.046)	-0.049 (0.051)	-0.243 (0.084)***	-0.575 (0.289)**	-0.900 (0.461)*		-0.049 (0.025)*
Initial Poverty	-0.036 (0.023)	-0.041 (0.025)	-0.008 (0.030)	0.171 (0.147)	0.294 (0.244)		0.016 (0.013)
(Initial) size Government		-0.022 (0.052)	-0.049 (0.072)		0.038 (0.373)	-0.062 (0.062)	0.001 (0.021)
Inflation		-0.000 (0.000)	0.000 (0.000)		0.000 (0.000)*		0.000 (0.000)*
Rural Population		-0.033 (0.098)	-0.293 (0.218)		0.130 (0.452)	-0.861 (0.150)***	0.008 (0.025)
Agricultural Employment		0.036 (0.032)	0.030 (0.036)		-0.028 (0.129)		-0.001 (0.007)
Trade		-0.070 (0.050)	-0.025 (0.062)		-0.523 (0.497)	0.149 (0.088)*	-0.029 (0.028)
Export -/- Import						0.000 (0.000)	
Observations	97	88	53	58	51	459	51
Countries						134	
OIR Test				0.72	0.99		0.93
F Test				0.003***	0.12		0.12
R-squared	0.97	0.97	0.97			0.31	

Table 7. Specific Channels of Private Credit: Impact of Private Credit on Several Agricultural Productivity Indicators

This table reports OLS estimations in Regressions (1)-(3) and (5)-(7), and a 2SLS estimation in Regression (4) for the period 1980-2003. All variables are in logs, except inflation. Regressions (1)-(4) have cereal yields (kg per hectare) as a dependent variable. Regression (5) has cereal yields *growth* as a dependent variable. In Regression (6), the dependent variable is the initial (on average 1981) crop production index (1999-2001=100). In Regression (7), the dependent variable is the initial (on average 1981) livestock production index (1999-2001=100). The main independent variable is private credit to GDP (percent). Other independent variables are the initial levels of GDP per capita, poverty, and government expenditure as a percentage of GDP in the period 1980-2003. Other controls are average inflation, average poverty, percentage trade of GDP, the percentage of the population living in rural areas, and the percentage of the workforce in agriculture. The 2SLS estimations use legal origin dummies indicating English, French, German, and Scandinavian law as instruments for private credit per GDP. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Cereal yield				Cereal yields growth	Initial crop yield index	Initial livestock index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Basic	Controls	Controls; poorest 50%	IV			
Private credit	0.084 (0.024)***	0.088 (0.025)***	0.110 (0.036)***	1.682 (0.890)*	0.003 (0.002)**	-0.131 (0.047)***	-0.091 (0.019)***
Initial cereal Yield	0.940 (0.045)***	0.899 (0.042)***	0.862 (0.066)***		-0.005 (0.003)*		
Initial. GDP/cap	-0.017 (0.035)	-0.062 (0.043)	-0.065 (0.073)	-0.440 (0.359)	-0.000 (0.003)	0.216 (0.067)***	0.074 (0.028)**
Initial Poverty	0.006 (0.021)	0.008 (0.021)	0.024 (0.028)	0.176 (0.262)	-0.000 (0.002)	-0.037 (0.038)	-0.005 (0.016)
Initial size Government		-0.128 (0.056)**	-0.184 (0.078)**		-0.011 (0.004)***		
Inflation		-0.000 (0.000)	0.000 (0.000)		0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Rural Population		-0.244 (0.078)***	-0.230 (0.200)		-0.013 (0.005)**	-0.029 (0.113)	0.003 (0.040)
Agricultural Employment		0.048 (0.018)**	0.053 (0.025)**		0.004 (0.001)***	0.065 (0.045)	-0.012 (0.015)
Trade		-0.014 (0.049)	0.049 (0.075)		0.001 (0.004)	0.219 (0.074)***	0.132 (0.031)***
Observations	96	87	52	58	87	88	88
OIR Test				0.74			
F Test				0.003***			
R-squared	0.89	0.92	0.87		0.20	0.40	0.42

Table 8. Specific Channels of Private Credit: Impact of Private Credit on the Use of Productivity Enhancing Equipment

This table reports OLS estimations in Regressions (1) and (3) and (6) and 2SLS estimations in Regressions (2) and (4) for the period 1980-2003. Regression (3), (6), and (7) report panel fixed effects estimations for the 1990s. All variables are in logs. In Regressions (1) and (2), the dependent variable is the log average fertilizer use in 100 grams per hectare. In Regressions (3) and (4), the dependent variable is the log average number of tractors per agricultural worker. The main independent variable is private credit to GDP (percent). Other independent variables are the initial levels of fertilizer use, number of tractors per agricultural worker, GDP per capita, and poverty. The 2SLS estimations use legal origin dummies indicating English, French, German, and Scandinavian law as instruments for private credit per GDP. OIR Test indicates the p-value of the Hansen overidentifying restrictions test, which has the null that the instruments are uncorrelated with the residuals of the second regression. F Test indicates the p-value of the F test with the null that the excluded exogenous variables do not explain cross-country variation in private credit to GDP in the first stage estimation. Regression (3), (6), and (7) area panel fixed effects regressions with on average 3.4, 3.4, and 2.7 observations per country, respectively. Additional control variables are food production per person (kg) food export -/- food import per person (kg). Standard errors are corrected for clustering at the country-level. White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Fertilizer use			Tractors per agricultural worker			Price index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	IV	Panel	OLS	IV	Panel	Panel
Private credit	0.441	1.616	0.002	0.244	5.522	0.140	5.801
	(0.069)***	(1.808)	(0.084)	(0.077)***	(2.076)***	(0.053)***	(9.053)
Initial fertilizer use	0.829	0.613					
	(0.058)***	(0.272)**					
Initial number of Tractors per worker				0.864	0.771		
				(0.084)***	(0.202)***		
Initial GDP/cap.	-0.155	-0.440		0.068	-1.716		
	(0.099)	(0.570)		(0.120)	(1.086)		
Initial Poverty	0.008	0.138		-0.186	0.699		
	(0.068)	(0.271)		(0.101)*	(0.708)		
Size Government			0.005			0.021	-41.016
			(0.172)			(0.107)	(36.449)
Rural Population			-0.627			-0.773	-19.886
			(0.259)**			(0.181)***	(38.800)
Food Production			0.859			0.358	-240.823
			(0.260)***			(0.189)*	(135.068)*
Export -/- Import			0.000			-0.000	0.101
			(0.000)			(0.000)*	(0.030)***
Observations	97	58	465	96	58	477	287
Countries			137			139	107
OIR Test		0.53			0.84		
F Test		0.23			0.05**		
R-squared	0.88		0.12	0.95		0.19	0.17

Table 9. Impact of Outreach of Financial Services on Undernourishment, Productivity, Use of Productivity Enhancing Equipment, and Food Prices

This table reports OLS estimations for the period 2001-2003. Dependent variables (all in logs) are prevalence of undernourishment (percent), Agricultural productivity per worker (in constant 2000 US$), Cereal yields (kg per hectare), Number of tractors per agricultural worker, Fertilizer use (100g per hectare), Price index, the average food price of rice, barley, outs, maize, wheat, pig meat, sheep meat, and chicken meat, weighted by their fraction of total production of these foods. The main independent variable is the log number of bank branches per 1,000 km^2 in 2003-2004. Other controls are private credit to GDP (percent), percentage trade of GDP, percentage government expenditures of GDP, inflation, food production per person (kg) food export -/- food import per person (kg). White (1981) heteroskedasticity-consistent standard errors are reported in parentheses. *, **, *** indicate significance at 10%, 5%, and 1% level, respectively.

	Undernourishment	Productivity	Cereal yield	Tractors per worker	Fertilizer	Price index
	(1)	(2)	(3)	(4)	(5)	(6)
Branches /1,000 km^2	-0.243	0.323	0.152	0.395	0.341	-24.941
	(0.058)***	(0.076)***	(0.040)***	(0.132)***	(0.091)***	(13.105)*
Private credit	-0.101	0.531	0.225	0.504	0.709	64.369
	(0.161)	(0.192)***	(0.071)***	(0.320)	(0.156)***	(21.265)***
Trade	-0.185	0.118	0.014	0.065	-0.186	58.525
	(0.265)	(0.282)	(0.111)	(0.461)	(0.229)	(34.194)*
Government	-0.700	1.163	-0.269	2.283	-0.494	-78.621
	(0.295)**	(0.395)***	(0.189)	(0.666)***	(0.315)	(76.186)
Inflation	-0.068	-0.006	-0.003	-0.000	0.092	-1.877
	(0.031)**	(0.045)	(0.022)	(0.089)	(0.051)*	(3.610)
Food production/cap.						-0.028
						(0.060)
Food export-import						7.468
						(18.603)
Observations	61	79	85	84	85	74
R-squared	0.24	0.47	0.45	0.36	0.51	0.14

Table 10. The Impact of an Increase in Private Credit on Undernourishment via Several Channels

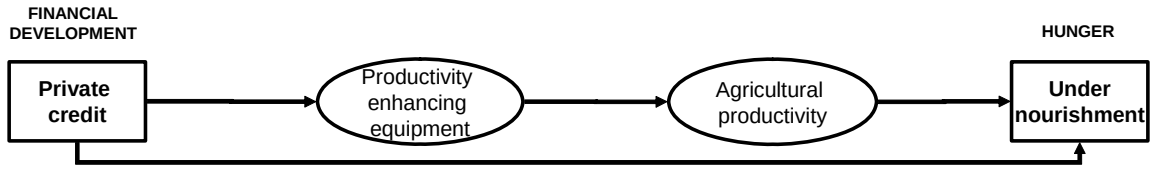
This table presents the predicted impact of a 1 percent increase in private credit to GDP on undernourishment via several channels (depicted in Panel B of Figure 1): 1) directly, 2) via productivity, 3) via fertilizer use and number of tractors per worker via productivity, and 4) via cereal yield. To calculate the effect of private credit to GDP on undernourishment via these channels, we use the coefficient estimates from our earlier analysis. The first column in the table report the effect in percent on the prevalence of undernourishment. In doing so, we use the OLS coefficients which include all country controls. The third column uses the coefficients of IV regressions which include all country controls. The second and fourth column indicate the impact explained by the specific channel as a percentage the direct channel. The percentages in parenthesis indicate the magnitude of the particular impact as a percentage of the impact via productivity directly.

Effect of a 1 percent increase of private credit on undernourishment:	OLS impact	Percentage	IV impact	Percentage
1. Directly (benchmark case)	-0.224	100.00	-2.448	100.00
2. Via productivity	-0.059	26.16	-1.347	55.01
3. Via fertilizer and tractors via productivity	-0.035	15.62 (59.71 of productivity)	-0.843	34.43 (62.59 of productivity)
4. Via cereal yields	-0.026	11.67 (44.59 of productivity)	-0.816	33.32 (60.58 of productivity)

Figure 1. Channels from Financial Development to Undernourishment

This figure shows the channels we test in this paper from financial development (private credit as a percentage of GDP), via productivity enhancing equipment (fertilizer use and number of tractors per agricultural worker), via productivity (agricultural productivity) to undernourishment (hunger). The numbers in Panel B refer to specific channels which are discussed in Table 10.

Panel A: Basic channels



Panel B: Expanded channels

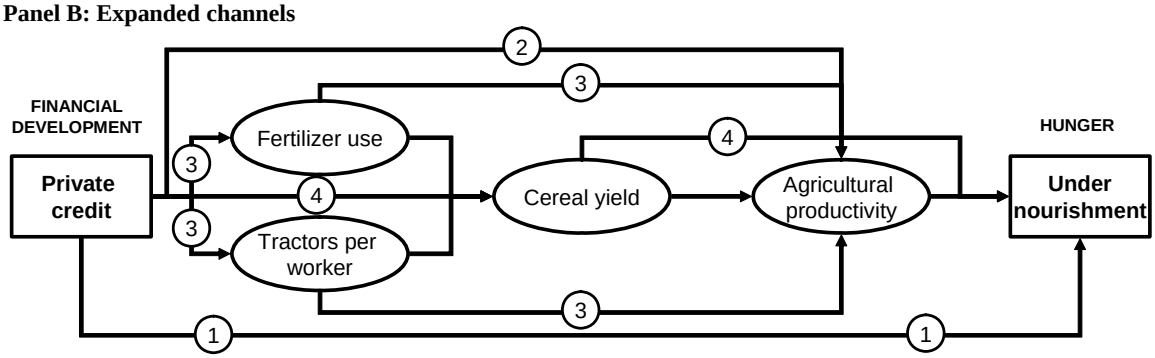


Figure 2. Private credit and undernourishment for the period 1980-2003

This is a plot of residuals. Undernourishment is the prevalence of undernourishment as a percentage of total population. Both variables were first regressed on initial GDP per capita, initial poverty, share of working population in agriculture, share of population living in rural areas, inflation, and trade as a share of GDP. Source: World Development Indicators (2005).

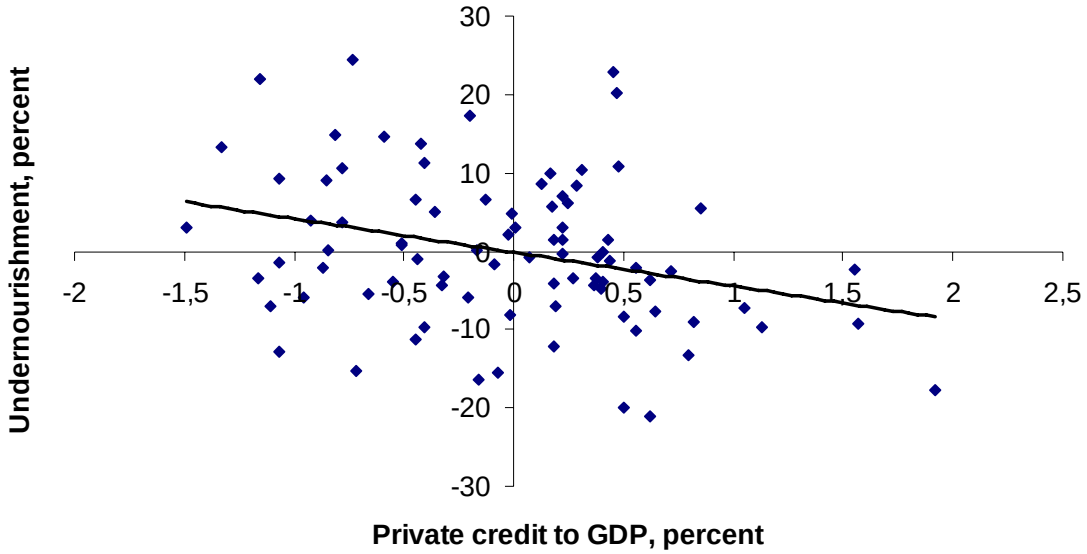


Figure 3. Agricultural productivity and undernourishment for the period 1980-2003

This is a plot of residuals. Value added is in constant 2000 dollars. First both variables were regressed on initial added value per agricultural worker, initial GDP per capita, initial poverty prevalence, inflation, and trade as a share of GDP. Source: World Development Indicators (2005).

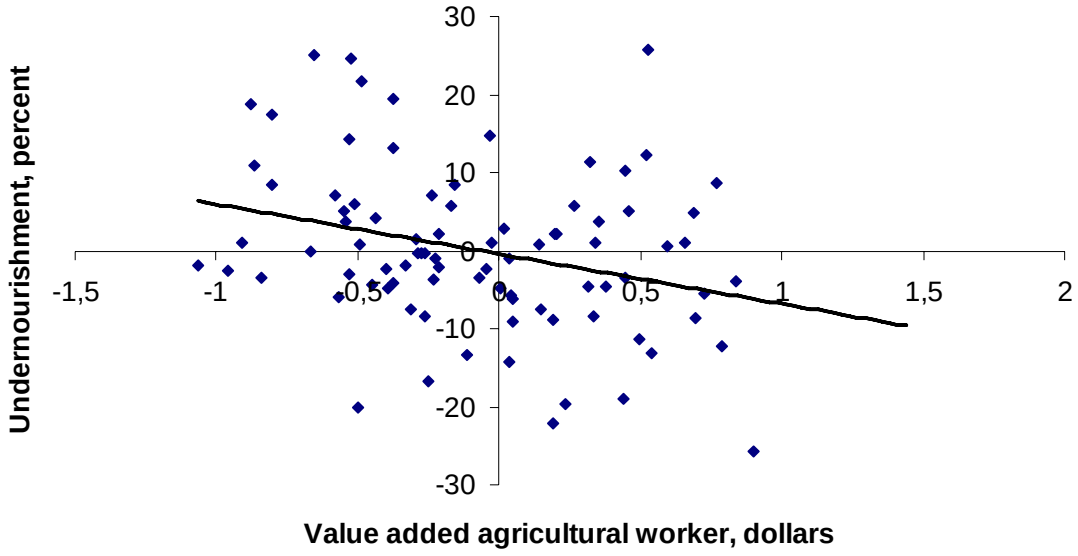


Figure 4. Private credit and agricultural productivity for the period 1980-2003

This is a plot of residuals. Value added is in constant 2000 dollars. First both variables were regressed on initial added value per agricultural worker, initial GDP per capita, initial poverty, share of working population in agriculture, share of population living in rural areas, inflation, and trade as a share of GDP. Source: World Development Indicators (2005).