Money and Development[1]

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Abstract

The inverse of velocity of money - the share of money in GDP - increases with income. We argue that this drop in velocity takes place because of a process of structural transformation - a shift of the economy away from agriculture towards non-agriculture. In particular we argue that agricultural goods in poor countries are characterized by a large degree of barter trade, whilst non-agricultural goods require money. We then explore the impact of varying interest rates on the start of structural transformation. We show that, in the data, governments of poorer countries tend to set higher nominal interest rates. Since, a positive nominal interest rate acts as a tax on cash-goods, agents substitute away from (monetary) non-agricultural products towards (non-monetary) agricultural products and thus delaying structural transformation. If TFP growth rates are low in the agricultural sector and high in the non-agricultural sector, there is an additional cost to deviations from the Friedman Rule (i.e. zero nominal interest rates) - a delay in structural transformation which results in lower growth rates.

[1] We would like to thank seminar participants at the University of Oxford for helpful comments and suggestions. All errors are our own. Email: radek.stefanski@economics.ox.ac.uk

1 Introduction

The velocity of money declines during development: poor countries exhibit higher velocity than rich countries. This is a relatively well known fact originally hypothesized by Friedman (1959):

> *Over long periods, real income per capita and income velocity (the ratio of income to the stock of money) tend to move in opposite directions.*

We argue that this is due to structural transformation, i.e. the shift of the economy from agricultural production towards manufacturing and services. This process modifies the types of goods that are exchanged: the economy goes from producing quite homogeneous agricultural goods that can be exchanged mostly through barter, to differentiated goods for which double coincidence of wants cannot be guaranteed and barter is therefore either impossible or very costly. Therefore, structural transformation generates a need for a higher quantity of money per unit of nominal GDP in order to facilitate trades, and velocity then declines. In other words, velocity of money decreases as an economy develops.

We first document the empirical evidence, showing that this phenomenon can be seen both in cross country and in time series data. [2] Then we rationalize this fact in a standard monetary model with structural transformation. We assume the economy has two sectors: agriculture and non-agriculture. In the first sector, agricultural goods are homogenous and therefore they are easy to trade even in the absence of money (with barter). In the second sector, goods are instead differentiated, therefore it is more complicated to barter. Hence, money is essential for trading in non-agricultural goods, and agents face a standard cash-in-advance constraint: they need money to buy non-food products.

Individuals have non-homothetic preferences for agricultural goods: there is a minimum level of calories that they have to ingest in order to survive. Goods are produced with labor, and labor productivity in the two sectors may differ. However, notice that if productivity is low in the agricultural sector, then a large fraction of the labor force must work in that sector in order to produce at least the minimum amount of food necessary for the survival. When the economy develops, productivity in agriculture increases, and labor moves to the non-food sector, generating a structural transformation.

In this model, Friedman's rule is optimal. Inflation is a specific tax on non-agricultural goods that distorts the margins for this sector, and slows the structural transformation process.

[2] We are not the first to look at this evidence. For example Driscoll and Lahiri (1983) look at several poor economies, and find support for decline in velocity in the large majority of them. They argue that as the share of the agricultural sector in GDP declines, then velocity declines. This implies, according to the authors, that there is the possibility of a noninflationary monetary expansion. Our model produces results in line of this explanation. Jonung (1983) documents the sharp decline of income velocity of money in Sweden between the 1870 and World War I. He underlines that this phenomenon can be explained by a switch from barter to monetary exchanges, and the consequent growth of commercial banking.

The optimum is reached when inflation tax is zero. i.e. with zero nominal interest rates. In other words, a positive nominal interest rate raises the price of non-agricultural products above their production costs. This results in agents substituting away from (monetary) non-agricultural products towards (non-monetary) agricultural products and thus delaying structural transformation. Therefore, inflation has long lasting effects on GDP and welfare.

However, the effects of inflation change at different stages of development. Low productivity levels in the agriculture (typically found in poor countries) result in a large, non-monetary agricultural sector. The impact of higher interest rates is then small at the aggregate level. Thus deviations from Friedman rule have little effects on growth for poor countries. At the contrary, the monetary sector dominates in rich countries, therefore changes in monetary policy will have a larger impact. We provide some evidence that these effects are at work in the real world.

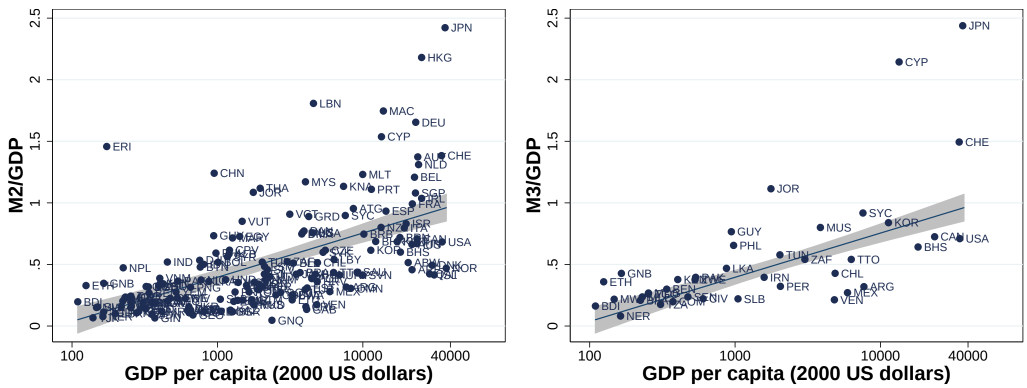
The work of Ireland (1994) is the closest to this paper. He presents a model of a monetary economy with cash-in-advance constraints, and an intermediation sector. However, his focus is more on the divergent dynamics of M1 and M2 during different stages of development, and the trade-off between using fiat money or credit arrangements for transaction. Our paper instead tries to understand the link between structural transformation and monetary aggregates, without introducing financial intermediation. Cooley and Hansen (1989) highlight the effects of inflation tax on capital accumulation. We abstract from this effect, since our mechanism based on structural transformation acts even in an economy without capital.

2 Facts

Velocity We start by considering how the share of money in GDP (or the inverse of the velocity of money) varies with income per capita. Figure 1 plots a cross-section of countries relating the share of money relative to GDP in an economy versus the income per capita of that economy for the year 2000. All data here come from the world bank. GDP per capita is shown in constant 2000 USD. In Figure 1(a), the measure of money is taken to be M2[3] , whilst Figure 1(b) considers a broader measure M3.[4] In each case, money is measured in local currency units, and the inverse velocity is simply the ratio of money to GDP (also measured in local currency units). A striking positive relationship emerges - richer countries have a higher share

[3] Defined (as in the WDI data) as both money and quasi money that comprise the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government.

[4] Defined (as in the WDI data) as the sum of currency and deposits in the central bank (M0), plus transferable deposits and electronic currency (M1), plus time and savings deposits, foreign currency transferable deposits, certificates of deposit, and securities repurchase agreements (M2), plus travelers checks, foreign currency time deposits, commercial paper, and shares of mutual funds or market funds held by residents.



(a) M2/GDP and income per capita.

(b) M3/GDP and income per capita.

Figure 1: Share of money in GDP versus GDP per capita (2000 USD) in 2000. (Source: WDI)

of money in the economy (or a lower velocity) than poorer countries. This fact is confirmed by the regressions (and the 5% error bands) shown in the figure.

This fact is not unique to the cross section. Figure 2, shows M2 shares and M3 shares over time in the United States. The long time series for Money and GDP (that terminate in 1999) come from Carter et al., eds (2006) whilst the more recent M2 data comes from the WDI. A similar rising trend exists as in the cross section.

Structural Transformation The premise of the paper is that the rise in money share (or the fall in velocity) is driven by changes in the type of goods produced by typical economies over the development process. A widely documented fact in the literature is that shares of employment and value added in agricultures fall with income. For example, Maddison (1982) presents evidence for this process for 16 industrialized countries since 1820-1973.[5] Echevarria (1997) provides examples of this pattern holding in cross-section. Duarte and Restuccia (2010) construct a panel of 29 countries for the period 1956-2000 and document the structural transformation (and its influence on aggregate productivity) in each of the countries over time.[6] In Figure 3(a) I reproduce the employment pattern for our cross-section WDI data, whilst Figure 3(b) demonstrated the same fact for the United States (1860-2004).

[5] The countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, U.K., and USA

[6] These include OECD countries such as Austria, Australia, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Turkey, U.K., and U.S. and Latin American countries such as Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela.

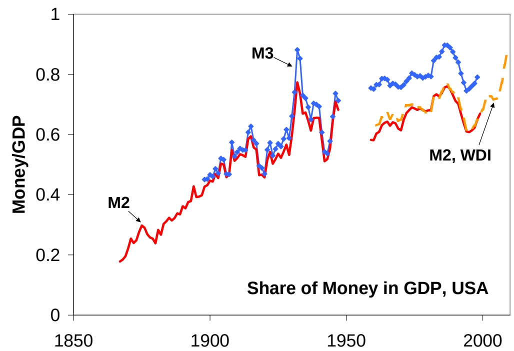
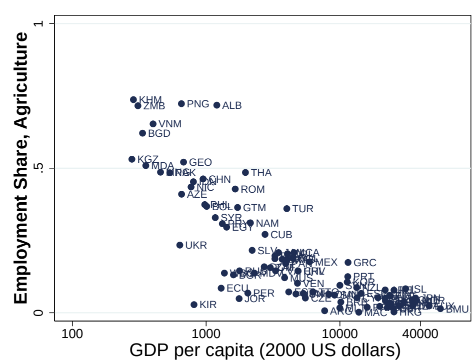
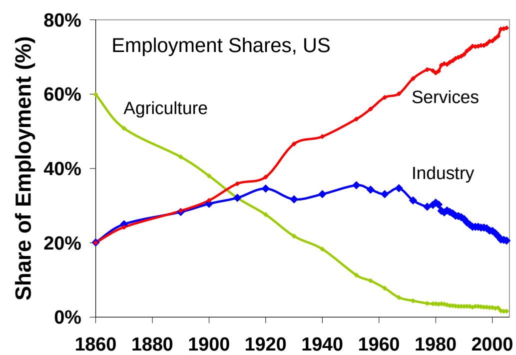


Figure 2: Share of money in GDP over time in the US. (Source: WDI, Carter et al., eds (2006))



(a) Cross Section



(b) USA

Figure 3: Share of employment in agriculture versus GDP per capita (2000 USD) in 2000. (Source: WDI)

Agriculture TO BE DONE
Evidence on levels of barter in agriculture: Carlin et. al. (1999).

3 Non-Monetary Problem

We start by describing a very simple, static, non-monetary problem of structural transformation from agriculture to non-agriculture. This demonstrate the mechanism through which structural transformation occurs in our model. For simplicity, we restrict our attention to a social planner's problem, although it is trivial to decentralize. The economy consists of two goods, agriculture and non-agriculture, and is endowed with a unit of labor. Both goods are produced in different sectors using (only) labor L_t^A in agriculture and L_t^C in non-agriculture. Both sectors also potentially differ in their exogenous growth factors of TFP given by g_A in agriculture and g_C in non-agriculture. The social planners problem is given by:

$$\max \sum_{t=0}^{\infty} \beta^t \left(\alpha \log(a_t - \bar{a}) + (1-\alpha)\log(c_t)\right) \tag{1}$$

$$\text{s.t.} a_t = g_A^t L_t^A \tag{2}$$

$$c_t = g_C^t L_t^C \tag{3}$$

$$L_t^A + L_t^C = 1. \tag{4}$$

Notice, that the characterizing feature of the agricultural sector, is the non-homotheticity of agriculture in preferences. There exists a subsistence level of agriculture, $\bar{a}$, that must be consumed every period. Intuitively, agents need to obtain a minimum quantity of agriculture (or calories), $\bar{a}$, each period to survive. When productivity in agriculture is low, in order to produce enough food, a large fraction of labor force must work in agriculture. When productivity in agriculture rises, the subsistence level can be met with a smaller fraction of the population. This leads to a shift of workers from agriculture to non-agriculture as agricultural productivity improves. We can solve the above model and find that the optimal employment share of employment in agriculture is given by the following expression:

$$L_t^A = \alpha + (1-\alpha)\frac{\bar{a}}{g_A^t B_A}, \tag{5}$$

which confirms the above intuition. As productivity in agriculture rises, employment in agriculture falls. In the long run (as $t \to \infty$) the employment share of agriculture is simply determined by the preference parameter α.

4 Monetary Problem

In this section we consider how adding money to the above problem changes outcomes. In particular we add another distinguishing feature across sectors. Workers now have to pay with money when purchasing non-agricultural goods. Agricultural goods however, can still be bought without money.

The intuition here is one of varying rates of double coincidence of wants across sectors. When the economy is poor (low agricultural productivity) a large fraction of the population is employed in agriculture and produces only agricultural products to provide the necessary calorie intake. We can simplify this world and assume that each type of agricultural product produces the same number of calories (i.e. marginal products are equated across sub-categories of food so that calories per hour worked are the same) but that each person produces a different variety of good. Essentially all agents want food to satisfy their subsistence levels. The sole motive for trade will be a taste for variety for different types of food. Instead of eating only apples, agents will prefer to eat apples and pears even though both fruit provide the same number of calories. Thus in a random matching framework, the condition for a trade in such a simplified agricultural world will be to meet someone who has a different product to you - as long as the two products are different, trade will occur. Since we assume that each person produces a different variety, every meeting will result in a trade. Since there will be no double coincidence of wants problem, money will not be necessary.

Non-agricultural products however, are far more complicated. Not only do they represent different varieties, they can also represent entirely different goods. There is thus a tendency for greater specialization of agents working in non-agriculture. Some agents will produce footballs, other books and others will be professors in economics. The motive for trade now, is not only taste for variety (I like different books), but also desire for different types of goods (I like books and footballs). In a random matching world, every meeting will no longer necessarily result in a trade. Thus the probability of a double coincidence of wants is smaller in a world with non-agriculture than in a world consisting entirely of agriculture. As such, there is a role for money to over come this friction.

For the moment, we abstract entirely from the above random matching world. Instead, we simply take as given that agriculture has no use for money, whilst non-agriculture does and we investigate the implications of this assumption in a simple cash in advance framework. In what follows we decentralize the problem of the previous section and add money. Overall, the problem is similar to Cole and Kocherlakota (1998) with an addition of a non-monetary sector (agriculture) and non-homothetic preferences in that sector.

Household's problem The representative agent's problem is shown below:

$$\max_{a_t, c_t, b_{t+1}, m_{t+1}} \sum_{t=0}^{\infty} \beta^t \left(\alpha \log(a_t - \bar{a}) + (1-\alpha)\log(c_t)\right)$$

$$\text{s.t. } p_t^a a_t + p_t^c c_t + b_{t+1} + m_{t+1} \leq w_t \bar{l} + (1 + r_t) b_t + m_t + T_t$$

$$p_t^c c_t \leq m_t$$

$$m_t \geq 0$$

$$b_t \geq -\bar{B}$$

$$\bar{l} = 1$$

The agent owns a unit of labor which it sells on the market for a wage w_t. In addition the agent comes into the period with money holdings m_t, bond holdings b_t (which he sells at a price $1 + r_t$) and receives a transfer of money from the government of T_t. Given this income, the agent chooses to purchase agricultural goods a_t (at the price p_t^a), non-agricultural goods c_t (at the price p_t^c), bonds b_{t+1} that promise to pay out $1 + r_{t+1}$ dollars next period and to hold a (non-negative) stock of money m_{t+1} for the next period. The reason to hold money, is the assumed cash-in-advance (CIA) constraint on non-agricultural goods which specifies that all non-agricultural goods must be paid for with cash. Finally, there is also a no-Ponzi condition on bonds.

Money Supply The government is assumed to have the following monetary policy:

$$M_{t+1} = T_{t+1} + M_t$$

Agricultural firm's problem Agricultural firms hire labor and produce according to the same technology as in the previous (non-monetary) section.

$$\max_{L_t^A} p_t^a A_t - w_t L_t^A$$

$$\text{s.t. } A_t = g_A^t B_A L_t^A$$

Non-agricultural firm's problem Non-agricultural firms also hire labor and produce according to the same technology as in the previous (non-monetary) section.

$$\max_{L_t^C} p_t^c C_t - w_t L_t^C$$

$$\text{s.t. } C_t = g_C^t B_C L_t^C$$

Market Clearing Finally, markets clear in a standard fashion.

$$a_t = A_t,\, c_t = C_t$$

$$m_t = M_t,\, b_t = 0$$

$$L_t^A + L_t^C = \bar{l}$$

Competitive Monetary Equilibrium For a given monetary policy, $\{T_t\}_{t=0}^{\infty}$, a competitive monetary equilibrium is a sequence of prices, $\{p_t^a, p_t^c, w_t, r_t\}$ and quantities $\{a_t, c_t, b_t, m_t, L_t^A, L_t^C\}_{t=0}^{\infty}$, such that given prices, quantities: satisfy 1) Household maximization 2) Firm maximization 3) Government budget balance and 4) Market clearing.

Solution We use μ_t and λ_t to denote the Lagrangian multipliers on the CIA and BC constraints, respectively. Since the households objective function is concave and its constraint set is convex, the households problem has a unique solution. This optimum is in turn the unique solution to the first order conditions and the transversality conditions on the stock variables. The first-order conditions consist of the BC and the CIA constraints, and

$$a_t\colon\ \frac{\alpha\beta^t}{a_t - \bar{a}} = \lambda_t p_t^a \tag{6}$$

$$c_t\colon\ \frac{(1-\alpha)\beta^t}{c_t} = p_t^c(\lambda_t + \mu_t) \tag{7}$$

$$b_{t+1}\colon\ \lambda_t = (1 + r_{t+1})\lambda_{t+1} \tag{8}$$

$$m_{t+1}\colon\ \lambda_t = \lambda_{t+1} + \mu_{t+1} \tag{9}$$

$$\text{CIA: } \mu_t(p_t^c c_t - m_t) = 0, \text{and} \mu_t \geq 0 \tag{10}$$

The firms' first-order conditions are:

$$p_t^a g_A^t B_A = w_t \tag{11}$$

$$p_t^c g_C^t B_C = w_t \tag{12}$$

Under this trading arrangement, there are five commodities traded in each period: agriculture consumption, non-agriculture consumption, labor, money, and bonds. The market-clearing conditions for the first four of these commodities are

$$a_t = g_A^t B_A L_t^A \tag{13}$$

$$c_t = g_C^t B_C L_t^C \tag{14}$$

$$L_t^A + L_t^C = 1 \tag{15}$$

$$m_t = M_t \tag{16}$$

Since bonds are private assets traded between households, bonds are in zero net supply. Hence, the bond market clearing condition is:

$$b_t = 0 \tag{17}$$

The transversality condition consist of:

$$\lim_{t\to\infty}\inf \lambda_t(b_t + B) = 0 \tag{18}$$

$$\lim_{t\to\infty}\inf \lambda_t m_t = 0. \tag{19}$$

Assumption 4.1. *Assume that interest rates are always positive, i.e.* $r_t > 0$*.*

The consequence of the above assumption is that the CIA constraint always binds. To see this divide 9 by 8 to obtain the expression for interest rates, $r_{t+1} = \frac{\mu_{t+1}}{\lambda_{t+1}}$. Thus, the nominal interest rate is positive if and only if money yields liquidity services ($\mu_{t+1} > 0$). In particular, if the nominal interest rate is positive, the CIA constraint is binding. We make this assumption because observed interest rates are positive.

Given the above assumption, equations 6-15 then define ten equations in ten unknowns (since the CIA constrain holds with equality) for which we next solve. In particular, these ten equations reduce to the following four:

$$\frac{\alpha\beta^t}{L_t^A - \frac{\bar{a}}{g_A^t B_A}} = \frac{\lambda_t M_t}{1 - L_t^A} \tag{20}$$

$$(1-\alpha)\beta^t = M_t(\lambda_t + \mu_t) \tag{21}$$

$$\lambda_t = (1 + r_{t+1})\lambda_{t+1} \tag{22}$$

$$\lambda_t = \lambda_{t+1} + \mu_{t+1} \tag{23}$$

We can then solve this and obtain:

$$\lambda_t = \frac{(1-\alpha)\beta^{t+1}}{M_{t+1}} \tag{24}$$

$$\mu_t = (1-\alpha)\left(\frac{\beta^t}{M_t} + \frac{\beta^{t+1}}{M_{t+1}}\right) \tag{25}$$

$$L_t^A = \frac{\alpha\tau_t + (1-\alpha)\frac{\bar{a}}{g_A^t B_A}}{\alpha\tau_t + (1-\alpha)} \tag{26}$$

$$r_t = \tau_t - 1, \tag{27}$$

where in the above $\tau_t \equiv \frac{1}{\beta}\frac{M_{t+1}}{M_t}$.

Rising Money Share First, notice as before, the model generates structural transformation from agriculture to non-agriculture as can be seen in equation 26. In particular, $\frac{\partial L_t^A}{\partial g_A^t B_A} < 0$ - thus as TFP increases in agriculture the employment share in agriculture falls (and hence the employment share in non-agriculture increases). The model also replicates our primary stylized fact: the rising share of money in GDP (or the falling velocity of money)

Theorem 1. *Given Assumption 4.1 the inverse of the velocity of money,* $V_t^{-1} \equiv \frac{M_t}{p_t^c c_t + p_t^a a_t}$ *is given by* $V_t^{-1} = L_t^C$.

Proof. By definition, $V_t^{-1} \equiv \frac{M_t}{p_t^c c_t + p_t^a \bar{a}} = \frac{p_t^c c_t}{p_t^c c_t + p_t^a \bar{a}}$, where the last equality holds since the CIA constraint binds by Assumption 4.1. Now, from the ratio of the firm's first order conditions, $\frac{p_t^a}{p_t^c} = \frac{g_C^t}{g_A^t}$. Hence, $V_t = \frac{1}{1+\frac{g_C^t}{g_A^t}\frac{a_t}{c_t}} = \frac{1}{1+\frac{L_t^A}{L_t^C}} = L_t^C$. ☐

Notice, that since the employment share in agriculture falls with agricultural TFP, the employment share in non-agricultural rises. Hence, the inverse of the velocity of money (the share of money in GDP) as TFP in agriculture increases. This matches the observed facts in the data.

Optimality How do the outcomes of this model compare with the non-monetary model? Notice that in both problems, the only (real) choice is the allocation of labor across sectors. By comparing equations 5 and 26 we see that employment shares will differ between economies as long as the nominal interest rate is positive, so that $\tau_t > 1$. Thus, as the government approaches the Friedman rule in the CIA economy, the CIA economy approaches optimality - i.e. as $\frac{M_{t+1}}{M_t} \to \beta$, the allocations of the CIA economy approaches the social planners problem.

Monetary Policy and Industrialization Next, we consider how government's decision to change the growth rate of the money stock affects structural transformation. Notice that

$$\frac{\partial L_t^A}{\partial \tau_t} = \frac{\alpha(1-\alpha)}{(1-\alpha+\tau_t\alpha)^2}\left(1 - \frac{\bar{a}}{g_A^t B_A}\right) \tag{28}$$

. This is greater than zero if and only if $g_A B_A > \bar{a}$, that is the initial technology is high enough so that if the entire labor force is devoted to agriculture it can satisfy the subsistence level (i.e. if everyone is working in agriculture, there is enough food to feed the entire population). Given that this survival assumption holds, the fact that $\frac{\partial L_t^A}{\partial \tau_t} > 0$, implies that governments that have a growing monetary base, will have a larger share of the workforce in agriculture than governments that have a declining or a constant monetary base. Another way to look at this (via equation 27) is that - holding agricultural productivity constant - countries with higher nominal interest rates will have higher employment in agriculture.

Monetary Policy in Rich and Poor Countries Another implication of 28, is that monetary policy will have different effects on employment allocation in rich and poor countries. In particular, defining $TFP_{A,t} \equiv g_A^t B_A$ using the above equation we can show that $\frac{\partial(\partial L_t^A/\partial \tau_t)}{\partial TFP_{A,t}} > 0$. In countries with higher agricultural productivity, the response of agricultural employment to a change in monetary policy, τ_t, will be larger than in countries with low agricultural productivity. The intuition is very simple. The allocations of the CIA model are the same as the allocations of a non-cash economy where a distortive tax, $\bar{\tau}_t = \frac{1}{\beta}\frac{M_{t+1}}{M_t}$ is levied on consumption of non-agricultural goods (and then lump-sum rebated to the consumers i.e. the budget constraint of the consumer in the non-monetary tax problem is given by:

$$p_t^a a_t + p_t^c \bar{\tau}_t c_t + b_{t+1} \leq w_t \bar{l} + (1+r_t)b_t + T_t$$

with the period by period budget constraint of the government being:

$$T_t = p_t^c(\bar{\tau}_t - 1)c_t.$$

Thus, in the above monetary framework, positive nominal interest rates act like a tax on non-agricultural goods. In countries that have no non-agricultural goods (i.e. countries with low agricultural productivity and hence low agricultural employment shares), a tax on non-agriculture will have very little impact. In richer countries were productivity in agriculture is high (and hence the non-agriculture sector is large), the inflation tax will have more of a bite and be a more distortive force in the economy.

The fit of the model Before we proceed with a calibration of the model and test it's quantitative significance, we perform a simple test of the above mechanism. We run a simple regression

VARIABLES	(1) Agr. Emp. Share
Agr. Productivity	-0.0041***
	(0.001)
Lending Interest Rate	0.0060***
	(0.002)
Observations	82
R-squared	0.348

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1: The impact of agricultural productivity and nominal interest rates on agricultural employment share.

on the cross country data to see whether - controlling for agricultural productivity levels - countries with higher nominal interest rates employ a larger fraction of their workforce in agriculture. The data again comes from the WDI. As our measure of nominal interest rates we take the lending interest rate in a country[7] and we take value added per worker in agriculture (in thousands of 2000 dollars) as our measure of agricultural productivity. We run the regression for the year 2000 (the year with the largest number of observations). The results are shown in Table 1 and confirm the intuition from our model. Richer countries with higher agricultural productivity have lower employment in agriculture. Countries however, with higher nominal interest rates tend to have a higher employment in agriculture. Thus the data seems to support that monetary policies can influence the real economy through the channel described above.

Calibration TO BE DONE

Welfare and Growth TO BE DONE

5 Conclusions

The modernization process of developing countries could be affected by monetary policy. We have shown that deviations from the Friedman rule in poor countries delay structural transformation, since inflation acts as a tax on non-agriculture goods and therefore discourage their production. However, effects change at different stages of development: countries with low agricultural productivity have small agricultural employment shares and therefore a tax on non-agriculture has small effects. Rich countries have high agriculture productivity, therefore tend to have large non-agricultural sectors and hence the inflation tax has larger impact.

[7] Defined as the rate charged by banks on loans to prime customers.

We need to calibrate the model to quantify these effects in terms of aggregate output, growth and welfare. In particular, it would be interesting to compare the effects of hyperinflations on two countries at different stages of development (e.g. Zimbabwe and Germany under Weimar Republic).

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