Welfare Implications of Expansionary Fiscal and Monetary Policy in a Monetary Corn Model

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Abstract

This paper examines the welfare implications of expansionary macro-policy in the context of a monetary corn model. It shows that under the assumption of decreasing returns to scale, output growth makes the worker worse off and the entrepreneur better off, even when the growth is triggered by a dole to the worker. In the same spirit, a positive technology shock that results in higher output and higher employment results in an improvement in the worker's welfare only if the magnitude of the shock is greater than a certain threshold. Expansionary monetary policy can result in a Pareto improvement via a decline in the interest rate. *

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1 Introduction

That growth in output can lead to greater inequality is part of the folklore of economics. Surprisingly, rigorous theoretical underpinning of this "folk theorem" is hard to come by. This paper presents a model in which growth in output systematically discriminates against the "workers" reducing their welfare, while enhancing that of the "entrepreneurs". This phenomenon is obtained even in circumstances where growth is triggered by a dole given to workers, or by a positive technology shock.

To demonstrate the propositions a finite horizon, general equilibrium corn model with money is developed. The paper presents a special case of the model presented in Dubey-Geanakoplos(1992) who get around the Hahn Paradox of fiat money having zero value in any finite horizon general equilibrium economy by introducing a central bank that stands ready to accept repayment of loans made to private individuals at the end of the world. While it belongs to the body of work related to the central questions of political economy, it differs from previous work in terms of scope, method, and conclusions.

It is faithful to the spirit of Ricardo(1817) who arrived at an inverse relation between the wages and profits. However it carries his argument to its logical conclusion in terms of the change in the *welfare* of workers and entrepreneurs. And this it does in the context of a general equilibrium model, unlike the partial equilibrium model of Ricardo who assumed a historically given wage rate.

It argues like Keynes(1936) that expansionary fiscal policy can increase the level of output in the economy. However, it does so without introducing involuntary unemployment with a downwardly rigid money wage.

It concurs with Keynesian business cycle theorists like Abraham and Haltiwanger(1995) that real wages are countercyclical, again without introducing rigidities in the labor markets, and extends their conclusions to the welfare of workers.

It departs from the conclusions of real business cycle theorists like Kydland and Prescott(1982) in whose model output growth fuelled by positive technology shock

leads to an increase in real wage. In this paper, both real wage and welfare can decline unless the technology shock is greater than a given threshold.

Its proposition that doles can make the recipient worse off harks back to the paper of Bhagwati(1956) on immiserizing growth, though here the doles are in terms of money. However, it is making a significantly different point in terms of the inverse relation between *output* and the welfare of the working classes. We show propositions in which doles given to the entrepreneur will make the worker worse off whenever they result in increased output.

Finally we demonstrate the possibility of Pareto improvement following growth triggered by expansionary monetary policy.

2 Intuition for results

In an economy with perfectly competitive labor markets, and profit maximizing firms, the marginal revenue product of labor must be equal to the wage rate. If we introduce a money market from which the entrepreneur borrows money to finance production, then the marginal revenue product of labor must be equal to the price of labor times the interest rate.

$$MP_l p_c = p_l(1+\theta)$$

With a concave production function MP_l declines with an increase in output. Therefore if output increases the real wage, i.e. $\frac{p_l}{p_c}$ must decline unless the interest rate declines by a greater proportion than the decline in MP_l. For example if interest rate stays constant or increases(as one would expect with an increased demand for money), the real wage must decline and the worker must be worse off.

Of course, if the trigger for the increase in output is an increase in the purchasing power of the workers(through a money dole), then it is not clear from the previous argument that the worker must be worse off. The resolution of this question we leave for the body of the paper.

The corn surplus and therefore the welfare of the entrepreneur can also be

expected to increase as the workers are able to extract a smaller proportion of the increased output due to the decline in their real wage.

3 Model

We consider a monetary economy lasting two time periods $t \in T = \{0, 1\}$. The economy consists of two types of households - entrepreneurs(E), and workers(W). There are two goods in the economy - labor-leisure l and corn c. Workers are endowed with L units of labor in period 1 and entrepreneurs possess technology that converts labor supplied by the worker in Period 1 into corn in Period 2. This technology is given by $f : R_+ \to R_+$ where f satisfies the assumptions of continuity, strict concavity, impossibility of free production, and possibility of no production. Workers like corn and leisure, while entrepreneurs like corn. The worker and the entrepreneur have utility functions $u^w : R^2_+ \to R$, and $u^E : R^1_+ \to R$ respectively. The utility functions satisfy the usual conditions of continuity and concavity. In order to ensure existence of equilibrium we assume that $\frac{MU^W_c}{MU^W_l}(l, 0) = \infty$ and that $\frac{MU^W_l}{MU^W_c}(0, c) = \infty$, i.e., both corn and leisure are "essential goods" for the worker. [1]

Money is the exclusive medium of exchange. It is fiat and gives no utility of consumption. Money enters the economy as private endowment of the entrepreneur $m^E > 0$ in Period 1, as dole given to the entrepreneur Δm^E and the worker Δm^E (outside money)and furthermore as money M at the bank available for the long term loan(inside money). The sale of q units of the long loan occurs before commodity trade in period 1, results in the acquisition of $\frac{q}{1+\theta}$ units of money and entails a promise to repay q units of money at the end of period 2. Without loss of generality(as we show later) we assume that the worker is not allowed to borrow on the long loan market. The government stands ready to supply the endogenously determined quantity of bank money M demanded by the households at the exogenously specified interest rate $(1 + \theta)$. There is no default in this model.

[1] For a less stringent assumption see the Gains to Trade assumption introduced by Dubey-Geanakoplos.

3.1 Government

The government fixes a policy consisting of a dole of private money to the worker and entrepreneur, Δm^W and Δm^E respectively, and a rate of interest $(1+\theta) > 1$. Thus government policy $\wp \equiv (\Delta m^W, \Delta m^E, 1+\theta)$. In addition the government prints M units of money to clear the market for long loans.

We could expand the role of the government to include the production of public goods using money raised through the sale of government bonds, which are repaid through taxes. However this extension is not relevant and therefore is omitted.

3.2 Sequence of Activities

3.2.1 Period 1

The following activities take place in the order listed:

(1) The long loan market meets.

(2) The labor market meets.

(3) The labor sold by the worker is employed in the production of corn.

3.2.2 Period 2

The following activities take place in the order listed:

(1) Production of corn is realized.

(2) The corn market meets.

(3) The long loan is repaid.

Let $q_l^W \equiv$ quantity of labor sold by a worker in Period 1, and $q_c^W \equiv$ quantity of corn demanded by a worker in Period 2. The set of actions available to the worker (q_l^W, q_c^W) is denoted by q^W. Let $q_l^E \equiv$ quantity of labor demanded by an entrepreneur in Period 1, $q_c^E \equiv$ quantity of corn sold by the entrepreneur in Period 2, $q_n \equiv$ quantity of long loan bought by the entrepreneur at the beginning of Period 1. The set of actions available to an entrepreneur (q_l^E, q_c^E, q_n) is denoted by q^E. Let $p_l \equiv$ price of labor, $p_c \equiv$ price of corn , $(1+\theta) \equiv$ long term interest rate. The set of prices in the economy $(p_l, p_c, 1+\theta)$ is denoted by p.

3.3 The Budget Set of a Household

3.3.1 Worker

We define A^W, the final allocation of a worker as follows: $A_l^W = L - q_l^W$, and $A_c^W = q_c^W$. The constraints on the set of actions q^W available to a worker given prices p are as follows:

In Period 1:

Labor sold to entrepreneur $\leq$ Labor endowment

$$q_l^W \leq L \qquad (1)$$

In Period 2:

Money spent on corn $\leq$ Wage Income + Dole from government to worker

$$p_c q_c^W \leq p_l q_l^W + \Delta m^W \qquad (2)$$

The set of allocations A^W corresponding to actions q^W that satisfy these constraints is denoted by $\Sigma^W(p)$ and is called the budget set of the worker.

3.3.2 Entrepreneur

We define A^E, the final allocation of an entrepreneur as follows: $A_c^E = f(q_l^E) - q_c^E$. The constraints on the set of actions q^E available to an entrepreneur given prices p are as follows:

In Period 1: Money spent on Labor $\leq$ Money endowment + Dole from government to entrepreneur + Money obtained on long term loan

$$p_l q_l^E \leq m^E + \Delta m^E + \frac{q_n}{1+\theta} \qquad (1)$$

In Period 2: Corn sold $\leq$ corn produced

$$q_c^E \leq f(q_l^E) \qquad (2)$$

Money earned from sale of corn $\leq$ Money owed to the bank on the long term loan

$$p_c q_c^E \leq q_n \qquad (3)$$

The set of A_c^E corresponding to actions q^E that satisfy these constraints is denoted by $\Sigma^E(p)$ and is called the budget set of the entrepreneur.

4 Monetary Equilibrium

A vector of allocations, prices and policy $(A^W, A^E; p)$ is a monetary equilibrium if:

(1) All households are optimal on their budget sets, i.e. for workers

$$A^W \in \Sigma^W(p)$$

and

$$\hat{A^W} \in \Sigma^W(p) \Rightarrow u^W(\hat{A}^W) \leq u^W(A^W)$$

For entrepreneurs

$$A^E \in \Sigma^E(p)$$

$$\hat{A^E} \in \Sigma^E(p) \Rightarrow u^E(\hat{A}^E) \leq u^E(A^E)$$

(2)All markets clear, i.e. in the labor market

$$q_l^E = q_l^W$$

In the corn market

$$q_c^E = q_c^W$$

In the loan market

$$M = \frac{q_n}{1+\theta}$$

From the existence theorem in Dubey-Geanakoplos, for an economy with $m^W + \Delta m^W + m^E + \Delta m^E > 0$, a monetary equilibrium exists.

4.1 Some properties of equilibrium

1. The worker will spend all the money at hand in the beginning of Period 2 on corn, else she will be left with unspent money. Thus constraint (2) of the worker's budget constraint will be satisfied with equality.

2. All the money in the system must be returned to the bank at the end of Period 2, else some agent is left with unspent money. Therefore $1 + \theta = \frac{M+\Delta m^W+m^E+\Delta m^E}{M} > M$.

3. The entrepreneur spends all the money at hand after the loan market meets on purchasing labor. If not, since interest rate is strictly greater than 1, she is merely inventorying the money borrowed to pay back the bank, and therefore having to lose for every ϵ units borrowed and inventoried, $\epsilon\theta$ units worth of corn. Therefore she could be better off reducing the amount borrowed by ϵ. Therefore equation (1) of her budget constraint must be binding.

4. As in the case of the worker, the entrepreneur will use all the money at hand after the corn market meets in Period 2, to repay her loan, else she will be left with cash in hand. Therefore constraint (3) of her budget constraint is binding.

5. Note that if we extended the model to allow the worker to borrow on the long loan market, atn equilibrium the worker will choose not to do so. If she borrows ϵ units, she will have to return $\epsilon(1 + \theta)$ to the bank. She will therefore have to withhold the money from corn purchases and sell and additional $\epsilon\theta$ worth of labor to pay back the loan. This will make her worse off.

5 Proposition and Examples

Proposition 1a: *For an economy with $\Delta m^W = 0$, suppose government boosts demand by giving a dole to the worker $\tilde{\Delta} m^W$ and simultaneously raising interest rate to $(1+\tilde{\theta})$ to clear the loan market. For any pair of equilibria, one pre-intervention and one post-intervention, the output of corn is higher in the post-intervention equilibrium, if and only if the entrepreneur is better off.*

Proof: In equilibrium the entrepreneur maximizes the difference between the corn output and the corn sold, i.e. $u^E = f(q_l^E) - q_c^E$.

From the entrepreneur's budget constraint,

$$q_c^E = \frac{(p_l.q_l^E - m^E)(1+\theta)}{p_c} \qquad (1)$$

From the entrepreneur's FOC for utility maximization,

$$MP_l = \frac{p_l(1+\theta)}{p_c} \qquad (2)$$

The entrepreneur must be spending all the money at the beginning of Period 1 on labor. Therefore the price of labor

$$p_l = \frac{M + m^E}{q_l^W} \qquad (3)$$

Substituting (1), (2), (3) in the expression for the entrepreneur's utility we get

$$u^E = f(q_l^E) - MP_l.q_l^E \frac{M}{M+m^E} \qquad (4)$$

Differentiating with respect to q_l^E we get

$$\frac{du^E}{dq_l^E} = MP_l \frac{m^E}{M+m^E} - \frac{dMP_l}{dq_l^E} q_l^E \frac{M}{M+m^E} \qquad (5)$$

Since f is strictly concave, $\frac{dMP_l}{dq_l^E} < 0$, and therefore $\frac{du^E}{dq_l^E} > 0 \quad \forall q_l^E$. Therefore when output increases if and only if the entrepreneur is better off.

Q.E.D

Proposition 1b: *For an economy with $\Delta m^W = 0$, suppose government boosts demand by giving a dole to the worker $\tilde{\Delta} m^W$ and simultaneously raising interest rate to $(1+\tilde{\theta})$ to clear the loan market. For any pair of equilibria, one pre-intervention and one post-intervention, (i) if the output of corn is higher in the post-intervention equilibrium, then the worker must be worse off. (ii) For linear utility, if the worker is worse off, then output must have increased post-intervention.*

(i) If output of corn has gone up, the marginal product (MP_l) must have gone down as f is strictly concave. This along with the entrepreneur's utility maximizing condition implies

$$MP_l = \frac{p_l(1+\theta)}{p_c} > \tilde{MP}_l = \frac{\tilde{p}_l(1+\tilde{\theta})}{\tilde{p}_c} \qquad (5)$$

From Equation (1) the price of labor pre-intervention $p_l = \frac{M+m^E}{q_l^W}$ and post-intervention $\tilde{p}_l = \frac{M+m^E}{\tilde{q}_l^W}$.

The worker must be spending all the cash in hand at the beginning of Period 2 on corn. Therefore the price of corn pre-intervention $p_c = \frac{M+m^E}{q_c^W}$ and post-intervention $\tilde{p}_c = \frac{M+m^E+\Delta m^W}{\tilde{q}_l^W}$.

All the money in the economy must be returned to the bank at the end of Period 2. Therefore the interest rate pre-intervention $(1+\theta) = \frac{M+m^E}{M}$ and post-intervention $1+\tilde{\theta} = \frac{M+m^E+\Delta m^W}{M}$.

Substituting the equilibrium values of prices and interest rates into (5) we get

$$\frac{q_c^W}{q_l^W} > \frac{\tilde{q}_c^W}{\tilde{q}_l^W} \qquad (6)$$

We now complete the proof by contradiction. Suppose the worker is indifferent or better off post-intervention. Then by revealed preference his post-intervention consumption point cannot be in the interior of his pre-intervention budget set. This implies

$$p_l(\tilde{q}_l^W - q_l^W) \leq p_c(\tilde{q}_c^W - q_c^W) \qquad (7)$$

(Note, the inequality is strict in the case the worker is better off)

Substituting the equilibrium values of p_l, p_c in (7) we get

$$\frac{\tilde{q}_c^W}{\tilde{q}_l^W} \geq \frac{q_c^W}{q_l^W} \qquad (8)$$

Equation (8) contradicts equation (6). Therefore the worker must be worse off.

(ii) Suppose the worker is worse off post intervention (with output decrease). Then by the reasoning of equation (6) it follows

$$\frac{\tilde{q}_c^W}{\tilde{q}_l^W} > \frac{q_c^W}{q_l^W} \qquad (9)$$

We know from part(i) of the proof that if (9) holds the post-intervention point is strictly outside the pre-intervention budget set. Therefore for linear utility, the post-intervention consumption point must be strictly preferred, and the worker must be better off, giving us a contradiction.

Q.E.D

To demonstrate the proposition 1 is non-vacuous we present an example of an economy where government intervention of the type considered leads to an increase in output.

Example 1: Consider an economy with the following parameters:

$$u^W(l^W, c^W) = min\{l^W + \frac{5c^W}{6}, \frac{240l^W}{171} + \frac{108c^W}{171}\}$$

$$u^E(c^E) = ln\ c^E$$

$$f(q_l^W) = \{ \begin{array}{l} 6.2q_l^W - .4(q_l^W)^2, \forall q_l^W \leq 7.75 \\ 24.025, \forall q_l^W > 7.75 \end{array}$$

$$L = 10; m^W = 0; m^E = 1; 1 + \theta = \frac{11}{10}$$

The following is an equilibrium in this economy:

$$q_n = 11; q_l^W = q_l^E = 5; q_c^E = q_c^W = 10$$

$$p_l = 2.2; p_c = 1.1;$$

Suppose the government gives a dole of 1 unit of money to the worker and simultaneously fixes $1 + \theta$ at 1.2.

The following is an equilibrium in the post-intervention economy at which output has gone up, the entrepreneur is better off and the worker is worse off:

$$q_n = 12; q_l^W = q_l^E = 5.5; q_c^E = q_c^W = 9$$

$$p_l = 2; p_c = \frac{4}{3}$$

Remark: In the example presented, the worker's share of the total corn produced has declined. It can easily be shown that whenever the output of corn goes up, the share of the worker in corn consumption, and indeed, the absolute amount of corn consumed by the worker, must decline.

Proposition 2: *For an economy with $\Delta m^W = 0$, suppose government boosts demand by giving a dole to the entrepreneur $\tilde{\Delta} m^E$ and simultaneously raising interest rate to $(1 + \tilde{\theta})$ to clear the loan market. For any pair of equilibria, one*

pre-intervention and one post-intervention, if the output of corn is higher in the post-intervention equilibrium, then (a) the entrepreneur must be better off and (b) the worker must be worse off.

Proof: (a)Note that an increase in $\tilde{\Delta}m^E$ is equivalent to an increase in m^E. Both result in an increase in the money in the hands of the entrepreneur at the beginning of Period 1. For ease of notation we discuss the case in which m^E has increased.

As in the proof of Proposition 1,

$$u^E = f(q_l^E) - MP_l q_l^E \frac{M}{M+m^E} \qquad (1)$$

Rewriting (1) to recognize that q_l^E is a function of m^E

$$u^E = f(q_l^E(m^E)) - MP_l(q_l^E(m^E)).q_l^E(m^E)\frac{M}{M+m^E} \qquad (2)$$

Differentiating with respect to m^E we get

$$\frac{du^E}{dm^E} = MP_l\frac{dq_l^E}{dm^E}(1 - \frac{M}{M+m^E}) - q_l^E\frac{M}{M+m^E}\frac{dMP_l}{dq_l^E}\frac{dq_l^E}{dm_l^E}$$

As $\frac{dMP_l}{dq_l^E} < 0$ (concavity of production function) and $\frac{dq_l^E}{dm_l^E}$(hypothesis of increased output), the derivative is positive for all m^E. The conclusion follows.

(b)The proof to show the worker is worse off is identical to the corresponding proof for Proposition 1(b)(i).

Q.E.D

Similar welfare effects can be observed in the case of a demand boosting intervention by government that does not increase interest rates as the following propositions demonstrate.

Proposition 3: *For an economy with $\Delta m^W = 0$, suppose government boosts demand by giving a dole to the entrepreneur $\tilde{\Delta}m^E$ and placing an additional amount of money at the bank to clear the loan market at the pre-intervention interest rate. For any pair of equilibria, one pre-intervention and one post-intervention, if the*

output of corn is higher in the post-intervention equilibrium, then (a) the entrepreneur must be better off and (b) the worker must be worse off.

Proof: (a) The proof is identical to the proof for Proposition 1(a) since we can treat $\frac{M}{M+m^E}$ as a constant.

(b) Identical to the proof for proposition 1(b).

Q.E.D

The model presented in this paper is not a growth model. However it does suggest that output growth can be welfare reducing for the worker, even if triggered by (apparently) welfare enhancing policies like doles.

It may be surmised that growth triggered by technology shocks will not have this nature as it results in an increase in productivity. The next proposition demonstrates that the impact of decreasing returns overweighs the productivity enhancing impact of superior technology, up to a certain bound.

Proposition 4: *Consider an increase in output and employment triggered by a technology shock that increases productivity by a factor of k. If $k < \overline{\alpha}$ then the worker must be worse off.*

Proof: Consider a production function f and a productivity enhanced production function $\tilde{f}$ such that $\tilde{f}(.) = kf(.)$.

From the concavity of f it follows that for every increase in employment from q_l^E to $\tilde{q}_l^E$, there exists an upper bound $\overline{\alpha}$ such that if $k < \overline{\alpha}$, then

$$\frac{d\tilde{f}}{dq_l^E}(\tilde{q}_l^E) = k\frac{df}{dq_l^E}(\tilde{q}_l^E) < \frac{df}{dq_l^E}(q_l^E)$$

$$\Rightarrow \tilde{MP}_l(\tilde{q}_l^E) < MP_l(q_l^E)$$

By the earlier argument for employer's FOC (see proof of Proposition 1(b)(i), equation 6), this implies

$$\frac{\tilde{q}_c^W}{\tilde{q}_l^W} < \frac{q_c^W}{q_l^W} \qquad (1)$$

But if the worker is better off after the productivity increase, by the worker's revealed preference, as in proof of Proposition 1(b)(i), equation 8

$$\frac{\tilde{q}_c^W}{\tilde{q}_l^W} \geq \frac{q_c^W}{q_l^W} \qquad (2)$$

This contradicts equation(1).

Q.E.D

Example 2: Consider an economy with the following parameters:

$$u^W(l^W, c^W) = min\{l^W + \frac{5c^W}{6}, \frac{240l^W}{171} + \frac{108c^W}{171}\}$$

$$u^E(c^E) = ln\ c^E$$

$$f(q_l^W) = \begin{cases} 6.2q_l^W - .4(q_l^W)^2, \forall q_l^W \leq 7.75 \\ 24.025, \forall q_l^W > 7.75 \end{cases}$$

$$L = 10; m^W = 0; m^E = 1; 1 + \theta = \frac{11}{10}$$

The following is an equilibrium in this economy:

$$q_n = 11; q_l^W = q_l^E = 5.5; q_c^E = q_c^W = 9$$

$$p_l = 2; p_c = \frac{11}{9};$$

Suppose productivity scales up by a factor of $\frac{22}{21}$ so that $\tilde{f}(q_l^W) = \frac{22}{21} f(q_l^W) \forall q_l^W$. The following is an equilibrium in the post-technology shock economy at which output and employment have increased, the entrepreneur is better off and the worker is worse off:

$$q_n = 11; q_l^W = q_l^E = 6; q_c^E = q_c^W = 8$$

$$p_l = \frac{11}{6}; p_c = \frac{11}{8}$$

Remark: If output goes up without an increase in hours worked, then it is easy to show that the worker must be worse off.

6 The Possibility of Pareto Improvement

Consider a policy intervention under which the government reduces interest rate and increases the stock of money at the bank to balance the money market. It is possible that both worker and entrepreneur are better off with output increase,

provided the percentage fall in the rate of interest is higher than the percentage fall in the marginal product.

Example 3: Consider an economy with the following parameters:

$$u^W(l^W, c^W) = min\{l^W + \frac{6c^W}{11}, \frac{1144l^W}{1134} + \frac{3380c^W}{6237}\}$$

$$u^E(c^E) = ln\ c^E$$

$$f(q_l^W) = 2.2q_l^W$$

$$L = 10; \Delta m^W = 1; m^E = 1; (1+\theta) = \frac{12}{10}$$

The following is an equilibrium in this economy:

$$M = 10; q_n = 12; q_l^W = q_l^E = 5; q_c^E = q_c^W = 10$$

$$p_l = 2.2; p_c = 1.2;$$

Suppose the government fixes $1 + \tilde{\theta} = \frac{13}{11}$, and simultaneously increases M to 11 to balance the loan market. The following is an equilibrium in the post-intervention economy at which output has increased and both the entrepreneur and the worker are better off :

$$q_n = 13; q_l^W = q_l^E = 6; q_c^E = q_c^W = 12.1$$

$$p_l = 2; p_c = \frac{130}{121}$$

7 Concluding Remarks

The paper attempts to explain the phenomenon of stagnant or declining real wages accompanied by output growth that has been observed in economies as diverse as the US and India. It concludes that output growth triggered by expansionary monetary policy(in the form of lower interest rates) can bring about Pareto improvement in the economy. On the other hand, output growth triggered by doles (to workers or to entrepreneurs) will always result in workers being worse off and entrepreneurs being better off.

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