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Commodity money and the price level

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Abstract

In an open free market economy with money based on a metallic standard, it is found that any shocks leave the price level unaffected in the long run, with the exception when the currency is debased. This stabilization property derives from the mechanism that changes in commodity prices motivate the holders of the stock of the currency to shift the latter's demand up to the point of equating the currency's cost of possession to its purchasing power. When the country is large relative to the international market for specie, maintenance of price stability may require adjustments in the seigniorage charge, whereas in countries with closed economies such adjustments are in general imperative. Also, through seigniorage adjustments, the price level may be held even fixed, and indeed irrespective of the magnitude and origin of shocks, the relative size of the country, and the degree of its openness. These results are consistent with the monetary experiences of Athens in classical times, France during the period 1350-1436 AD, Spain in the 16th century, the United States in 1870-1914 AD, and China in 1910-1935 AD. Additionally, given that electronic money like the Bitcoin has properties similar to commodity money, the results may extend to a cryptocurrency standard.

Keywords: Commodity money, inflation, deflation, stabilization,

JEL Codes: E31, E42, E51, E63, N13

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1. Introduction

The term "commodity money" refers to products like gold and silver, which have been used in the past for exchange of goods and store of value purposes. In the 20th century, and particularly after the collapse of the Bretton Woods agreements in 1971, when the convertibility of the U.S. dollar to gold ended, with few exceptions, the interest of monetary economists in commodity standards eclipsed, and instead they focused on fiat money in conjunction with the presumed stabilizing powers of governments and central banks. Economists following the monetarist tradition cannot be absolved of their responsibility for this development. For, say, when Friedman (1953, 209-210; 1960, 5) wrote that,

> The fundamental defect of a commodity standard, from the point of view of the society as a whole, is that it requires the use of real resources to add to the stock of money. People must work hard to dig gold out of the ground in South Africa—in order to re-bury it in Fort Knox or some similar place."

Friedman, most likely committed to his assessments in Friedman (1951), missed the opportunity to throw his weight in favor of a commodity reserve standard based entirely on futures, which would eliminate the social costs he was so concerned with the gold standard.[1] Now we live in a world of fiat money, negative interest rates, and huge public and private debts, so thinking ahead of the next big crisis, research efforts to increase the pool of alternative policy options, including the return to commodity money, should be welcome.

Another reason for looking into this issue is certainly the developments in the front of crypto-currencies or cryptos. Many proponents insist that currencies like Bitcoin are indeed "digital gold". Their claims are not unwarranted. The similarities of cryptos to gold or silver are not limited to the fact that they have intrinsic value, due to the significant energy consumed in their production. Additionally, once possessed by somebody, exactly like any commodity money, they cannot be in any way another person's liability. In other words, unlike fiat money, the value of which is based on the credibility of the issuing government, in the case of cryptos there is no trust involved. If one holds bullion, the only way one loses ownership is by selling it or by losing it to thieves. Cryptos have

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[1] The idea of a basket of commodities standard is not new. It is an extension of the concept of "symmetallism" first proposed by Marshall (Marshall 1887, 204-7). According to it, all money would circulate in the form of banknotes convertible into gold or silver ingots joined together in fixed proportions. The market would determine a weighted average of the prices of these metals and both would remain in the reserve base. In this way, the standard would not degenerate into monometalism. Still the problem of production and storage costs mentioned in the quotation by Friedman would continue to exist. However, these costs might be eliminated completely following the design and operation of schemes based of futures, as discussed in Barro (1979, 20-31) and in more exhaustive detail in Dowd (1995, 309-339).

the same exact property. Once in one's wallet, they cannot be cloned and they stay firmly in one's possession. For example, the only way Bitcoin leaves one's grasp is either through sale, theft, or losing in some way one's wallet. Drawing on these specie like advantages of cryptos, experts do not preclude that an electronic currency like the Bitcoin may emerge as a world currency. Are these prognoses farfetched? Not even by a little bit. For, even though it is quite early to tell how the introduction of Bitcoin and numerous other cryptos will integrate into the national and international monetary system of payments, from the sheer interest central banks show in the digital currencies, there is no doubt that sooner or later electronic commodity money will push aside fiat money as per the inverse of Gresham's law.

In view of this prospect, the objective here is to investigate the implications of commodity money for the stability of the level of prices in an open free market economy. To this effect, next section presents the model and its analysis. To anchor the presentation to a realistic case, the setting of the model is envisioned to draw on the experiences of countries like Athens in classical times or the United States today, that is, large relative to their trading partners. The rationale being that in the advent of sizable supply or demand shocks their effects might possibly spread internationally and influence the price of the precious metal used in their currency standard. Section 3 highlights the equilibrium properties of the proposed model and states the findings in the form of a theorem. Then, in Section 4, the applicability of the theorem is validated by reference to certain well researched historical country episodes, and finally in Section 5 the paper closes with a summary of the findings and the conclusions.

2. Setting of the problem and analysis

Consider an open economy with a silver standard named "drachma" and traded goods and services as depicted in the following expression.

$$(x_1, x_2, x_3, x_4, x_5, ..., x_h, x_{h+1}, x_{h+2}, ..., x_m). \tag{1}$$

Let x_1 stand for a quantity of silver drachma coins, x_2 for a quantity of silver bullion, x_3 for a quantity of gold bullion, $(x_{h+1}, x_{h+2}, ..., x_m)$ for a basket of consumer goods, and $(x_4, x_5, ..., x_h)$ for a basket of all other goods. The ratios of goods x_i, for $i = 2, 3, ..., m,$ to the drachma coins x_1 give the *relative prices*. Using these relative prices, assume that all consumer goods are aggregated into a basket of consumer goods of quantity c and price p_c^d. The latter, standing, say, for the well-

known Consumer Price Index (CPI), denotes the quantity of silver drachmae or fraction thereof one needs in order to purchase one unit of c. At the same time, the inverse of p_c^d, that is $1/p_c^d$, stands for the price of the monetary unit in terms of the quantity of consumer goods it buys, that is, its real purchasing power. Therefore, by definition, it holds that:

$$p_d^c \equiv 1/p_c^d. \tag{2}$$

This identity describes the accounting function of money. It defines the value of the drachma as the reciprocal of the unit price of the consumer goods that it buys. Hence, it holds irrespectively of the material of which drachma is made in order to serve its other functions, that is, those of the medium of exchange and store of value.

The latter bring us to the possession cost of the drachma coin. Since the standard under consideration is one of silver, let it be denoted by f_d^c. This cost comprises four components. The first is the cost of silver contained in the drachma coin, k_1^c. The second is its fabrication cost, k_2^c. The third, k_3^c, represents the tax that the mint collects on behalf of the issuing state;[2] and lastly, the fourth component, k_4^c, stands for the value of the services that the drachma coin offers by enabling its bearer to carry out market transactions and to store value. In other words, $f_d^c = k_1^c + k_2^c + k_3^c + k_4^c$. Of the four components that enter into f_d^c, k_1^c is determined in the international market for silver; the value of k_2^c depends on the operating costs of the mint; k_3^c is a policy instrument in the sense that it is decided by the official commodity money issuing authority, and lastly k_4^c, to be called just for reference purposes "brand premium",[3] is determined in the international markets for foreign currencies.

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[2] This tax is the well-known "seigniorage". In the case of the U.S. dollar, Eichengreen (2011, 3-4) has coined the term "Extravagant privilege" and justifies it as follows:

> …It costs only a few cents for the Bureau of Engraving and Printing to produce a $100 bill, but other countries have to pony up $100 of actual goods and services in order to obtain one. (That difference between what it costs the government to print the note and a foreigner to procure it is known as "seigniorage" after the right of the medieval lord, or seigneur, to coin money and keep for himself some of the precious metal from which it was made).

[3] In the case of commodity money, aside of the seigniorage charge, which burdens both domestic and foreign holders of the currency, international markets would place on it a premium, depending on how well it performs relative to other international currencies as medium of exchange and store of value. For example, in the case of Athens in classical times there is evidence showing that foreign merchants who brought their goods to the port of Piraeus, they sold them at significant price discounts to customers who paid in Athenian currency. These discounts determined the magnitude of the "brand premium" that the markets placed on the drachma.

In view of their underlying determinants, f_d^c and p_d^c may differ due to various economic circumstances. Therefore, given that the wedge between them generates for the holders of the stock of drachma coins opportunities for gains and incentives for avoidance of losses, there arise two questions. These are, first, if p_c^d changes due to demand or supply shocks in the markets for consumer goods, would the emergence of inflation or deflation be permanent or transient? and second, if f_d^c changes due to non-compensating shifts in its determinants, how might these changes affect the price level p_c^d? To answer these questions, we need a theory based on the rational economic behavior of economic agents who are active in the economy.

A convenient approach to such a theory is to hypothesize that the purchasing power of drachma and the cost of its possession adjust in a way that, after some reasonable time, they converge to an equilibrium. Adopting this conceptualization, let

$$\dot{p}_d^c = -\lambda(\overline{p}_d^c - f_d^c) \tag{3}$$

where $\lambda > 0$ and a dot (bar) over a variable denotes, respectively, its time derivative and equilibrium value. Equation (3) is a stable first order differential equation which converges to $\overline{p}_d^c = f_d^c$. The idea underlying (3) is that a disturbance in p_d^c, say dp_d^c, motivates economic agents to act so that, as the disturbance dies out, $dp_d^c \to 0$, p_d^c returns gradually to its equilibrium value, $p_d^c \to \overline{p}_d^c$. While at the microeconomic level there are markets which once hit by a shock release forces that lead to the establishment of a new equilibrium, at the economy level equation (3) is considered by macroeconomists adequate (see e.g. Alogoskoufis 2019, 370), because shocks do not hit all markets at the same time and on the average the effects of negative and positive shocks phase out gradually in more or less short time.

Turning to the possession cost of the drachma, subject to the remarks that will follow, let:

$$\dot{f}_d^c = -\mu(f_d^c - \overline{f}_d^c), \tag{4}$$

where $\mu > 0$. Again this is a stable first order differential equation that converges to $f_d^c = \overline{f}_d^c$, and together with (3) yields a second order system that converges to:

$$\overline{f}_d^c = \overline{p}_d^c. \tag{5}$$

Embedded in equation (4) is the conceptualization that shocks in f_d^c motivate economic agents to

act such that $f_d^c \rightarrow \overline{f}_d^c$. Yet in this case there is a problem, because the implication that the shocks in f_d^c converge smoothly to $\overline{f}_d^c$ conflicts with the experiences under the real gold standard that applied presumably before World War I and was characterized by the following stylized facts:[4]

- In the decades leading to the close of the 19th century, the discovery of new gold mines and the improvement in the technology of extracting gold increased its world supply relative to demand, and the possession cost of gold declined.

- However, the increase in the supply of gold could not keep-up with the much faster increase in the supply of goods, due to the accelerating productivity, and as a result this imbalance led to serious deflation.

- Lastly, given that, first, the prospects for accelerating the production of gold from ever twiddling and more expensive to mine gold deposits were dim; and second, that the presumed effects from the deflationary spiral were construed to be economically and socially intolerable, the gold standard was replaced by systems of "pseudo" gold standard, which initially adhered to the convertibility of government issued paper money into gold, but after 1971 convertibility was abandoned altogether in favor of fiat money.

Consequently, if a case can be made for returning to a commodity money standard[5] as a better system for preserving price stability, this hinges on establishing that (5) remains stable to shocks like those that led to the abandonment of the gold standard.[6]

3. Stability of the equilibrium

The holders of the stock of drachma coins in the economy, rationally thinking, should have an

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[4] To distinguish the government driven gold standard that applied in the U.S. before 1914 and the various forms of "pseudo" gold standards that were adopted after this date and up to 1971, Friedman (1961) used the term "real". The discussion in Sub-section 4.4 below casts some doubts as to the nature of the gold standard that prevailed in the U.S. even before 1914.

[5] The choice of a path for returning to a commodity money standard is not without its own difficulties. More recently, Selgin (2015) introduced an important differentiation between systems of gold standard that are based on "public law" and systems based on "private or customary law", in which the government does not mingle up with the functions of money. In classical Athens evolved a silver standard in between the "real" and the "custom" type ones. Under the Athenian silver standard, the state intervened only to express in law the custom-driven rules that favored the preservation of the integrity of the Athenian coins that circulated in parallel and in competition with the coins that were issued by other city-state jurisdictions. Legislation regarding this, say, "true" silver standard was propelled from below, not imposed from above.

[6] Aside from the stability of $\overline{f}_d^c$, under which the price level would be expected to remain trendless or without persistent inflation or deflation, the analysis will extend to the case where $\overline{f}_d^c$ is held fixed through appropriate seigniorage policies. In the latter event, the level of prices would be expected to remain constant.

incentive to minimize losses, when $\bar{f}_d^c < p_d^c$, and maximize gains, when $\bar{f}_d^c > p_d^c$. By reducing (increasing) respectively their purchases of consumer goods, the price of the latter will increase (decline), the purchasing power of money will decline (increase) and eventually all adjustments will come to an end by establishing equilibrium as per equation (5). So, let us return to the questions raised above and investigate whether this equilibrium remains stable or not upon a disturbance from various hypothetical shocks.

3.1 Shocks from productivity improvements in the supply of consumer goods

Due to keen competition among firms in the consumer goods sector, assume that all improvements in productivity are passed on to consumers in the form of price reductions. Alternatively, this implies that the firms in this sector retain no abnormal profits. The decline in the price of consumer goods increases the purchasing power of the drachma coin above its equilibrium value, and hence above its equilibrium possession cost. The situation that arises is $\bar{f}_d^c = \bar{p}_d^c < p_d^c$. Will this shock give rise to deflation? The holders of drachma coins and assets denominated thereof are offered certain windfall gains. So, behaving rationally they may be expected to transfer silver from other non-monetary uses, including dishoarding of commodity money and even use good substitute means of payment like gold, to expand their purchases of consumer goods. Moreover, since the economy is presumed to be open, the decline in the domestic prices of consumer goods will render them more competitive relative to those abroad and export demand will increase; inflows from exports will increase the commodity money supply in the domestic markets; higher profit margins and productivity gains in the silver producing domestic industry may induce further increases in the supply of the commodity money; and all these adjustments should continue until the price of consumer goods returns to $\bar{f}_d^c = \bar{p}_d^c$, thus establishing that the price of consumer goods remains stable.

In a small country with an open free market economy and commodity money this result holds with certainty because, the self-correcting adjustments mentioned above cannot be expected to exercise any decisive influence on the international price of silver k_1^c, and $\bar{f}_d^c$ remains fixed. But, if the economy is large relative to the world market for specie, it cannot be precluded that a productivity shock will not stir deflation. The reason is that, due to the scale of the country in the international market for specie, excess demand will increase its price, k_1^c will move upwards, and in

turn $\bar{f}_d^c$ will shift to a new higher equilibrium such that $\bar{f}_d^c < \bar{\bar{f}}_d^c = \bar{\bar{p}}_d^c > \bar{p}_d^c$. Selgin (1990, 1997) and Dowd (2017, 39) argue that in this case a productivity shock will lead to deflation, whereas Yeager's (1992, 59-60) thinks that prices will remain stable. The present setup offers another approach to making sure that productivity shocks do not give rise to deflation in large countries. It is based on the seigniorage charge. Notice in this regard that, by shifting k_3^c in a compensatory manner, the commodity money issuing authority may hold $\bar{f}_d^c$ fixed in the same way that Williams (1892) proposed long ago.[7] If one is sensitive to the possibility that this authority may exercise undue discretion over the adjustment of this instrument, the policy may be relegated to an automatic feedback rule. What matters is that in exceptional cases when shocks in large countries or in the production of specie introduce havoc in its international market, rampant inflation or deflation may be avoided by changing the seigniorage charge k_3^c to keep $\bar{f}_d^c$ fixed. Moreover, aside from this meritorious stabilization property, the suggested approach offers superior flexibility to deal prudentially with the spillovers of shocks that hit third countries.

Lastly, if a country's economy is closed, the self-correcting adjustments become subdued and most likely they will fail to raise the demand for consumer goods sufficiently to push p_d^c back to the equilibrium level. Then, if price stability is the objective, the suggested policy approach becomes imperative. For, shifting k_3^c appropriately upwards, increases f_d^c and, by speeding up the velocity of circulation of the commodity money, deflation comes to an end at a new higher equilibrium such that $\bar{f}_d^c < \bar{\bar{f}}_d^c = \bar{\bar{p}}_d^c$. In this case though, responsible for the emergence of deflation would be the arrangements that rendered the economy closed rather than the shocks from the improvements in productivity. The analysis of shocks that enter through the demand of consumer goods follows modes of thinking like the above and leads to analogous findings. Therefore, without further ado, let us turn to the next most important issue.

3.2 Shocks through the supply side of the market for specie

Looking closer at equation (5) in conjunction with the determinants of the possession cost of the commodity money, one cannot miss that shocks channeled through f_d^c are key to the stability of the equilibrium, and hence to the stability of the level of prices. For, if the shocks are such that the

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[7] I am indebted to Kevin Dowd for bringing this source to my attention.

equilibrium of f_d^c shifts, say to $\overline{f}_d^c \neq \overline{\overline{f}}_d^c$, then depending on whether $\overline{f}_d^c > \overline{\overline{f}}_d^c$ or $\overline{f}_d^c < \overline{\overline{f}}_d^c$, the price level will go into inflation or deflation, unless the disequilibrium generates incentives that motivate economic agents to undertake initiatives to bring about the convergence of f_d^c to $\overline{f}_d^c$. Thus, given that the nature and the implications of the shocks through the supply side of the market for specie lie at the center of the problem, their analysis is most important.

To this effect, it serves best our purpose to consider the case that transpired in Athens in 483 BC. In that year they discovered a new rich vein of silver in the nearby Laurion region; its production expanded spectacularly; and at least during the period 480-430 BC Athens was elevated to the top world supplier of silver. Consequently, the international price of silver ought to have declined, k_i^c shifted downwards, and the lowering of the drachma's possession cost led to a disequilibrium situation $f_d^c < \overline{f}_d^c = \overline{p}_d^c$. Did they experience persistent inflation and if not why? The disequilibrium certainly motivated Athenians to bring about the following adjustments: a) since the economy was open, the rise in the price of consumer goods stimulated imports; b) competition from imports pushed the price of consumer goods back to $\overline{p}_d^c$; c) paying for the cost of imports in currency and bullion and curtailing the production of silver as well as discouraging its monetarization, due to the decline in the purchasing power of the drachma, certainly reduced the excess supply of silver. Were these adjustments enough to prevent the decline of k_i^c and hence the shift of f_d^c to a lower inflationary equilibrium? The answer is found in the following quotation from Xenophon (*Ways and Means,* IV, 3-8):

> Well, so long as the maximum number of workmen was employed in them (Author: he means the mines), no one ever wanted a job; in fact, there were always more jobs than the labourers could deal with. And even at the present day no owner of slaves employed in the mines reduces the number of his men; on the contrary, every master obtains as many more as he can. The fact is, I imagine, that when there are few diggers and searchers, the amount of metal recovered is small, and when there are many, the total of ore discovered is multiplied. Hence of all the industries with which I am acquainted this is the only one in which expansion of business excites no jealousy. Further than this, every farmer can tell just how many yokes of oxen are enough for the farm and how many labourers. ..… But an increase in the amount of the silver ore discovered and of the metal won is accompanied by an increase in the number of persons who take up this industry. Neither is silver like furniture, of which a man never buys more when once he has got enough for his house. No one ever yet possessed so much silver as to want no more; if a man finds himself with a huge amount of it, he takes as much pleasure in burying the surplus as in using it (Underlined by the author).

According to the testimony of this astute student and observer of economic development at the time, demand for silver was practically insatiable. Therefore, given that the Athenian economy was open and there was no excess international supply of silver, in all probability the discovery of the Laurion silver mines left the equilibrium at $\overline{f}_d^{\,c} = \overline{p}_d^{\,c}$ and the level of prices steady.[8]

3.3 Debasement of the currency

In this case, the state purposely issues new coins with lower content in silver. When the new coins appear in the market for consumer goods, their price in the new currency duly increases, so that the value of the new currency in terms of consumer goods declines, and thus a new long run equilibrium is established in which the price of consumer goods has increased permanently. Still there is a problem, because the old currency contains more silver and hence it commands higher value in terms of purchasing power. The circumstances are such that the holders of the old currency either proceed to remint the currency in their possession or, driven by Gresham's law, they hoard it, or the markets split into one dealing in the old currency and another dealing in the new currency. In all cases though there is another long term equilibrium with a higher price level.

3.4 Sum up

In a country with commodity money, the stability of the level of prices depends on two conditions. These are, first, whether the country is small or large relatively to the international market for silver, and second, whether the country's economy is open or closed. Expressing more compactly the implications of these conditions, yields the following theorem.

> **Theorem**
> In a country with open free market economy and commodity money, the price level remains stable in the long run under any shock, excluding the debasement of the currency. If the country is large relative to the international market for specie, preserving price stability may require adjustments in the seigniorage charge, whereas if the country's economy is closed, regardless of the country's relative size in the market for specie, maintenance of price stability renders such adjustments imperative. Through seigniorage adjustments, the price level may be held even fixed, and indeed irrespective of the magnitude and origin of the shocks, the relative size of the country, and the degree of its openness.

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[8] Presumably, prices would remain stable under productivity improvements in the economy and particularly in the mining and processing industries of silver. In the case of classical Athens, there is evidence showing that improvements at the purification stage of silver ores resulted in significant gains in the quantity and quality of the extracted silver bullion.

What remains is to find how well this theorem applies by reference to historical country episodes for which we have enough information about the nature of the currency that was used and the course of prices. But before turning to this task a note is in order. According to the theorem, if the economy is closed, the effects of shocks are not shelf-correcting. Hence, all policy interventions through the possession cost of the commodity money to confront persistent price instabilities are second best to keeping the economy and its markets as open and as competitive as possible.

4. Empirical validation of the theorem

The above theorem was deduced from the assumption that rational economic agents act to maximize windfall gains or minimize windfall losses when circumstances drive a wedge between the possession cost of the currency and its purchasing power in terms of consumer goods. As such the theorem may be considered as absolutely true. But then arises the question: Is this theorem "true" in the same sense as those of algebra and geometry, or is it merely probable, like the propositions of literary economists? The answer is that there exists a fundamental difference. This amounts to the qualification that, while the theorem may be considered absolutely true, at the same time though the model itself and the underlying assumptions may not be applicable to any real world phenomena, and this in turn may render the theorem vacuous. Therefore, to make sure that the theorem is useful, we must supplement it with a proposition specifying the real world situation(s) to which it applies. This proposition may be called an applicability or empirical accountability theorem and as such it is highly probable but never absolutely certain. In this section the objective is to assess the applicability of the derived theorem by looking at certain historical country episodes, which have attracted particular attention in the literature.

4.1 Athens in classical times

In the period 480-430 BC, the Athenian economy was exposed to two huge streams of silver flows. The one emanated from the mines in the nearby Laurion region and the other from the tributes Athens received from its allies in the context of the First Athenian Alliance for leading the collective defense of Greek city-states against the Persians. A similarly huge inflow of precious metals repeated again in the 4th century, but not earlier than 330 BC, originating in the treasures of gold and silver that Alexander the Great captured from the Persians and distributed to Athenians who had followed him in his expedition to Asia and returned to Athens. As we argue elsewhere, for 300 years the currency was never debased, Gresham's law held in reverse, and

the drachma had been established in the eastern Mediterranean and beyond as the select medium of exchange and store of value. In other words, as the U.S. dollar today, it enjoyed a brand or royalty privilege.

The evidence is that the mint in Athens fabricated exquisite designs of coins, with high productivity, implying relatively low fabrication cost, and the seigniorage was kept relatively low in competition to the mints of the other city-states. These advantages, in conjunction with the plentiful supply of silver bullion, must have shifted the production, and hence the possession cost of the drachma much lower than before. Did the shock from the supply of silver result in a significant permanent inflation? Figueira (1998, 493) rates the likelihood of inflation quite high. He suggests that the working hypothesis should be that Athenians experienced significant inflation in the 5th century, because it is unlikely that the supply of goods and services increased in proportion to the increase in the money supply. Instead, the conclusion reached in Sub-section 3.2 and the following theorem driven analysis suggests a different interpretation for whatever inflation there was.

Before silver from the Laurion mines appeared in the form of currency, bullion and bank deposits, mining and processing of silver ores expanded employment and incomes, and hence GDP. The latter's composition would have changed and with it certainly the relative prices. But the aggregate demand for goods and services should have increased pretty much in proportion with their aggregate supply. For, if the prices for foodstuffs and other household and enterprise implements increased in the short-run due to supply of silver induced excess demand, profit margins would have increased and, by stimulating in the medium run imports, paid for by the plentiful supply of silver, prices would have returned to their previous long run equilibrium. Hence, if there was significant inflation, it could not have come from the supply of domestically produced commodity money. Still, the evidence is that significant inflation may have emerged from the way in which the city-state of Athens applied the large inflows of allied tributes. Illuminating in this regard is the following quotation from Loomis (1998, 243):

> The possible c. 50% rise in wages from c. 450 to 432 would be the natural result of enormous tribute revenues pouring into Athens year after year. With the transfer of the *treasury of the Delian League* from Delos to Athens by 453 and the elimination of the Persian military threat by the Peace of Kallias in 449, more money was available for expenditure in Athens itself, for (the raw materials for) public works, and for the wages of public officeholders, soldiers and sailors, and public construction workers. The increasing amount and circulation of this money, in the context of a (presumably) less rapidly increasing labor supply, would have been the cause of the wage increases in this period.

In other words, the state raised the wages of public magistrates, soldiers and sailors across the board; it spent lavishly in the construction of luxurious public buildings and city beautifications; it established programs of social welfare, festivals and other cultural activities, etc. In turn, rising wages in the public sector raised the wages and the cost of materials in the private sector; as the latter entered into a phase of cost-push inflation, the drachma lost purchasing power; the miners of silver lost incentives and curtailed their efforts; the supply of domestically produced commodity money declined; and, eventually, when the allied tributes declined to a trickle and Athens did not have money to prepare for the Peloponnesian War, the price level returned to its long run equilibrium.

4.2 France 1350-1436 AD

Sussman, Zeira (2003) have examined the effects of repeated debasements on the price of the commodity money and the level of prices in France during the so-called period of Hundred Years War, which spanned the period from 1350 to 1436 AD. They find that:

> … commodity money can be inflated similarly to fiat money through repeated debasements, which act like devaluations. Furthermore, as with fiat money, demand for commodity money falls with inflation. However, at high rates of inflation demand for commodity money becomes insensitive to inflation, since commodity money has intrinsic value in addition to its transactions value.

In Sub-section 3.4, it was established that upon debasement the price level increases permanently, and that in turn the purchasing power of the debased commodity money declines to a new long run equilibrium. This prediction from the simple model in equation (3) is consistent with the first finding in the above quotation. The second empirical finding is that the demand for the inflated currency falls. Again, drawing on the rational behavior of economic agents, in Sub-section 3.4 it was argued that markets may split into those dealing in the new and those dealing in the old currency. By implication, the demand for the new debased currency may be expected to fall. Perhaps, this is what happened in the period under consideration each time a debasement took place. For, if on the contrary the normal was for the holders of the good currency to remint it upon debasement, the demand for the new debased currency might as well have increased. Finally, there is the finding regarding the differentiation of the demand for the debased commodity money at low and high rates of inflation. The proposed model cannot shed light on this issue because it is too simple to capture the expectations that economic agents develop in the context of repeated debasements of different size.

From the above, it turns out that the theorem is consistent with the empirical findings regarding the debasement of currency induced inflation in this historical country episode.

4.3 Spain in the 16th century

In the Sub-section 3.4, it was established that, in the advent of a supply shock that increases the quantity of the commodity money in excess of the available goods, the price level remains stable, if and only if the economy is open. The theorem provides explicitly for this condition. Hence, its relevance may be validated by contradiction, namely, by reference to the case of a country with a closed economy where, upon a positive shock in the supply of commodity money, the price level increased. Most suitable for such a test is the case of Spain in the 16th century, also known as Spanish Price Revolution, because the coincidence in this period of a huge influx into Spain of silver treasures from Latin America with a trend increase in the rate of inflation has attracted intense research attention.

From the voluminous literature in this area, it sharpens the requirements for the validation of the theorem, if we consider the findings by Kugler, Bernholz (2007), which have passed a particularly demanding set of statistical tests. Among other European countries, to which the Spanish Price Revolution spread, the authors focus on the relationship of commodity prices to the money supply in Spain over the period 1500-1600. More specifically, they fit a structural vector autoregression model to data on commodity prices and the money supply in the Spanish regions of Old Castile and Leon and New Castile, and they find credible evidence that the increase in the commodity prices at the rates of 1.1 and 1.4% per annum, respectively, was induced by the expansion in the money supply due to the above mentioned influx of silver specie. Based on these and similar results obtained, for example, by Fisher (1989), one would be compelled to conclude that the theorem did not apply in Spain at the time, since the influx of huge quantities of silver caused a secular increase in inflation at rates that were not as low as they would seem to us today. However, on closer consideration one can hardly miss that the estimates from these studies derive from statistical models that do not account in any way for the fact that the Spanish economy during this period was closed. To understand how tightly the institutional arrangements insulated the import-export borders of the country, the following quotation from Lynch (1991, 175) should suffice:

> Spain was already a protectionist country, barricaded with customs, and a government which theoretically controlled everything entering and leaving its frontiers was unlikely to allow the new-found treasure to escape its grasp. But the monopoly, and the at-

tempts to preserve it, were not perfect: there were frequent complaints from the cortes that the continual exit of precious metals-'as if we were Indians'-was impoverishing the country, and it was commonly said that Spain was 'the Indies of other countries'. Yet there were many reasons why the precious metals should escape from Spain and circulate abroad. Spain was primarily an exporter of raw materials and an importer of manufactured goods; with an unfavourable trade balance, she had to settle her payments with ready cash.

In this light, the theorem did retain its relevance in Spain, but its working was vitiated by the administrative walls that Spanish governments erected to prevent the free flow of importing and exporting activities. Expectedly, had the researchers in these studies been able to allow in their models for the import-export constraints, the estimated coefficient of the money supply variable would not be different than zero.

4.4 United States, 1870-1914 AD

In the period 1792-1834 the United States (U.S.) was officially on a bimetallic standard of silver and gold at the ratio of 15 to 1.[9] Additionally, a number of foreign coins had been declared legal tender and circulated in parallel with the U.S. dollar. But not long after the first Coinage Act of 1792, the price ratio of silver to gold increased to 15½ to 1 and, as gold became more expensive and grew relatively scarce due to exports, the standard turned effectively into one of silver. With the Coinage Act of 1834, the U.S. Congress sought to remedy the problem by changing the mint ratio of silver to gold to 16 to 1. This time though, the new policy made gold cheaper relative to the world market price ratio, silver began to be exported, and after a few years the standard became one of gold. At the same time, as there emerged shortages in fractional coins, the U.S. Congress authorized in 1853 the cutting of silver coins which were made legal tender for amounts less than $5. Thus, in the period before the Coinage or Mint Act of 1873, the standard was bimetallic comprising large denominations from gold and small denominations from silver.

The latter Act, although somewhat inadvertently, ended bimetallism by abolishing the right of silver bullion holders to have their metal struck into silver and placed the U.S. on the gold standard. However, in the following years, as the world production of silver continued to expand relative to gold, mainly farmers in coalition with the opponents of the state's monopoly on gold reserves managed through political pressure to convince the federal government to buy repeatedly large quanti-

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[9] For a more detailed documentation of the history of commodity money in the U.S., see Elwell (2011). Moreover, note that henceforth the abbreviation AD is omitted.

ties of silver and coin them into silver dollars. This period of actual bimetallism lasted until the U.S. Congress authorized the Gold Standard Act of 1900, which provided for the free coinage of gold and full convertibility of currency into gold coins. Then, in 1914, the U.S. government suspended this regime, so that it could print enough money to pay for the expenditures of World War I; it reestablished it in 1919 upon the end of the war; and, finally, as it became the scapegoat for the great depression of 1929, in 1933 the gold standard was abandoned.

Now from Barro (1979, 29) we know that as long as the relative prices of the two metals can adjust freely, bimetallism or symmetallism preserves the property of price level stability . Hence, if the theorem were relied upon to predict the course of prices during the 1870-1914 period, these ought to remain fairly trendless. Figure 1 shows that this was actually the case. From 1870 to 1895
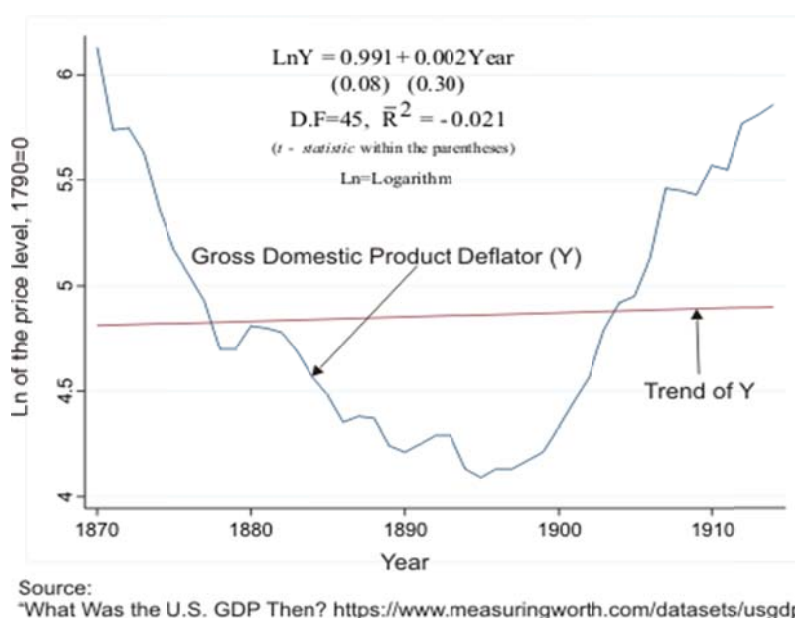

$$LnY = 0.991 + 0.002\,Year$$
$$(0.08) \quad (0.30)$$
$$D.F=45, \quad \bar{R}^2 = -0.021$$
(*t* - *statistic* within the parentheses)
Ln=Logarithm

Gross Domestic Product Deflator (Y)

Trend of Y

Source:
"What Was the U.S. GDP Then? https://www.measuringworth.com/datasets/usgdp/

Figure 1: The price level in the U.S., 1870-1914

prices declined. From 1896 to 1913 prices increased; and if a trend was estimated over the whole period, as the horizontal straight line indicates, the level of prices did not follow any persistent tendency to decline or to increase. Moreover, it should be noted that this finding is robust to different measurements of the price level as well periods over which the test is carried out going backwards. For example, Martin (2017) uses the GDP deflator and the consumer price index, extending the period of testing as far as back as 1790, whereas Alogoskoufis (2019, 23, 24) employs the indices of consumer and retail prices going back to the first half of the 19th century. Both find that the level of prices before WWI was trendless. In the words of the latter author:

> There was no systematic inflation and the price level did not display a particular trend until World War I, because for most of this period, both the United States and the United Kingdom had adopted metallic monetary systems, based on precious metals (specie), such as gold and silver. Such metallic systems constrained the rate of growth of the money supply. When they were forced to temporarily abandon such systems, as during wars, both countries sought to return to such systems as soon as possible. (*ibid*, 24)

Furthermore, it is reassuring to point out that the empirical evidence validates the applicability of the theorem, despite the realization that U.S governments during this period applied highly distortionary policies like the following:

- The U.S. Mint intervened as buyer or seller to defend at times of bimetallism a select price ratio of gold to silver and at times of monometalism a select price of gold. By doing so, it attempted to control the developments in the free markets for the two metals. But this is an impossible task, because even the most sophisticated planning bureau is short of the required divine faculties. Hence, by entering into this game, U.S. governments applied models of "pseudo" commodity standards, which they changed frequently to suit the expediencies of those who were in power over the years.

- In the period following the Coinage Act of 1873, the price of silver was declining rapidly and certainly silver could have been used as a good substitute to combat the increasing scarcity of gold. Yet the Act eliminated the monetary use of silver in anything but fractional currency. In Figure 1, this explains the initial phase of deflation, which rendered the Act contentious and some denounced it as the "Crime of 1873". As for the second phase of reflation, this coincided with accelerated coinage of silver in the early 1890s.

- Beyond the above, U. S. governments instituted arrangements that distorted gravely free banking and turned the state into a major part of the problem instead of a means to solving it.

In conclusion, what is surprising is not that the empirical evidence validates the theorem, but that it does so in the advent of currency policies which should have aggravated significantly the excessive and protracted variability of the price level.

4.5 China, 1910-1935 AD

The last country episode to test the validity of the theorem is China in the period 1910-1935 AD. At a time when Western countries were on the gold standard, in 1910 AD China acceded formally to a currency standard based on silver. Kreps (1934, 249) and Hu (2013, 49) inform us that the latter's application was so much different from region to region that one might reasonably doubt

whether a silver standard was applied at all. However, despite the chaotic complications introduced in everyday transactions by the plethora of coins minted following different accounting units and silver content, currency markets certainly should have established exchange rates among the various coins, so that some sort of silver standard did apply until 1935 AD, when China abandoned it and switched to fiat money.

Drawing on these brief remarks, an interesting question to start with is: why did China elect to adopt silver instead of gold? The relevant literature provides various conjectures. For example, a few are that traditionally household and enterprises had been accustomed to use and accumulated valuables in silver, that the Chinese government at the time lacked knowledge of the international monetary system and the changes that it was undergoing, and that because China was frequently in wars, its governments did not have the time to pursue reforms in the country's monetary system. Yet, while there may be some truth in these claims, the following reasons suggest that the decision to adopt silver rather than gold was taken on solid economic analysis grounds:

- For all practical purposes, China produced neither gold nor silver in materially significant quantities. Hence, whichever of the two precious metals was adopted, the necessary quantities would have to be imported.

- If the estimates discussed by Kreps (1934, 255-257) regarding the stock of silver that was held by the Chinese people in the forms of ornaments, bullion and coins were anywhere near the actual figures, then during the period under consideration this large stock would have render any decision to adopt the gold standard baseless.[10]

- Since China was large relative to the international silver market, even small demand and supply shocks originating from China would affect significantly the price of silver, and hence the possession cost of silver coins f_d^c.

- Lastly, given that China at that period was the only country on the silver standard, whatever demand and supply shocks for non-monetary uses of silver that emanated from the rest of the word would exercise limited influence on the international silver market, and hence China might rest assured that it would be the sole major player in this market for monetary silver.

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[10] According to Chang (1988, 87-88) the stock of silver held by China in 1933 was estimated at 2.5 billion ounces, or 22% of the world's visible stock, ranking the country second in the world after India. This stock of silver is very close to the estimates discussed by Kreps (1934, 255-257).

With the above in mind, let us now turn to the relationship of the price of silver to the price level over the said period.

Figure 2 exhibits the developments in the fronts of the price level and the international price of silver over the period in which China applied the silver standard. The price level is measured by the Wholesale Price Index (WPI) in the region of Shanghai. However, it should be noted that roughly the same results would have emerged, if the available data from the region of Canton were employed. On the other hand, the international price of silver is measured in Chinese dollars per ounce of silver. The long term trends of the corresponding variables have been computed using linear regressions. In both cases the trend lines explain over 98% of the variance in the dependent variables and the parameter estimates meet all classical statistical tests. Observe that that the trend line of the international price of silver after 1932 jumps violently upwards. This break is captured by a dummy variable and reflects the impact of the silver purchasing program that was instituted late in 1933 in the United States.[11]
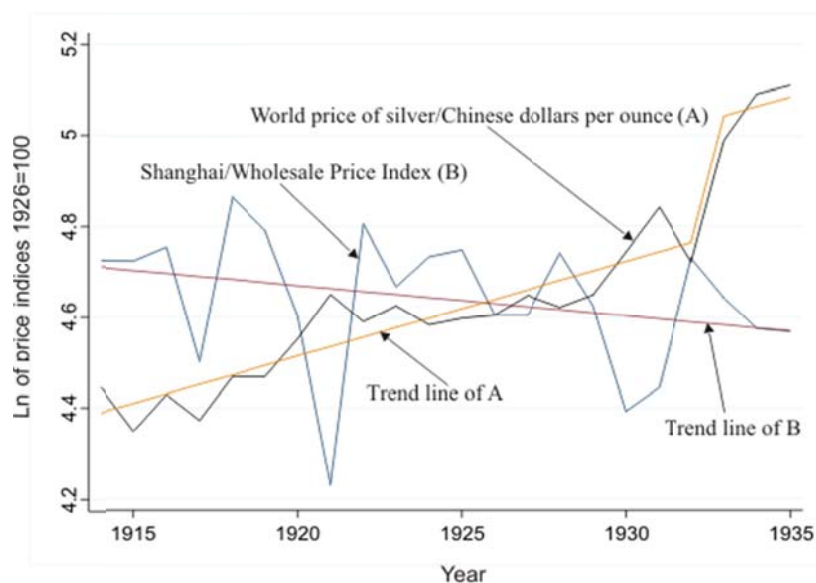
Data sources: 1. Data for (B) comes from the Institute of Economics, Shanghai Academy of Social Sciences, A Compilation of Price before and After Liberation in Shanghai, 1959, Shanghai People's Publishing House, 4,126,175.
2. (A) was obtained using the series "Price of silver in U.S. dollars per ounce," and "exchange rate of U.S. dollar to Chinese dollar" from Chang (1988),

Figure 2: The price level under the silver standard in Shanghai/China

From the slopes of the two trend lines it follows that, as it would have been expected, the price level declined in the same period that the price of silver increased. In particular, given the large size

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[11] For the politics that led to this policy in the United States and its international ramifications, particularly with regard to the regime change in China, see Friedman, Schwartz (1963), Friedman (1992), and Brandt, Sargent (1988).

of China relative to the international silver market, the accelerated imports of silver throughout the 1910s and 1920s were bound to put upward pressure on the international prices of silver. Hence, as per the theorem, to avoid the deflation shown by the downward trend of the Wholesale Price Index, China ought to have adopted policies to hold the possession cost of the Chinese dollar stable. Having failed to do so in the period before 1932, when the annual increase in the price of silver was mild, it was certainly asking for too much to begin the heavy intervention that was required when the international price of silver skyrocketed in the following years due to the silver purchasing program introduced in the United Sates, which in turn raised precipitously the exports of silver from China. In conclusion, the explanatory power of the theorem is perfectly validated by the case of the silver standard in China during the said period.

5. Summary of findings and conclusions

It was found that in an open free market economy, given any shock with the exception of debasement, a decentralized monetary regime based on a metallic standard has the intrinsic stabilization property to leave the price level steady. This property derives from the realization that rising (falling) commodity prices lead to a fall (rise) in the purchasing power of the currency and, by creating windfall losses (gains) to holders of the stock of currency and assets thereof, they motivate them to reduce (increase) the currency demand for monetary purposes up to the point of equating the currency's cost of possession to its purchasing power in terms of goods and services. Also, it was found that: a) when a country is large relative to the international market for specie, maintenance of price stability may require appropriate adjustments in the seigniorage charge, whereas in countries with centralized management of the commodity money or closed economies such adjustments are in general imperative; and b) through such seigniorage policies, the price level may be held even fixed, irrespective of the magnitude and origin of shocks, the relative size of the country, and the degree of its openness.

The above predictions from the adopted model, expressed compactly in the form of a theorem, were assessed for relevance in the context of the monetary experiences of Athens in classical times, France during the period 1350-1436 AD, Spain in the 16th century, the United States in 1873-1910 AD and China in 1910-1935 AD. In all cases it turned out that the predictions were consistent with the available empirical evidence, thus validating the explanatory power of the model. Additionally, it emerged as an issue for future research that, in related econometric appli-

cations, researchers should allow for the relative size of the country under consideration in the international market for specie as well as for the degree of "openness" of its economy.

Finally, two remarks are in order. The first is that the results are not tied necessarily to metallic standards, since technically the value of the monetary unit can be based on the share value of a portfolio comprising the main resources used in the production of GDP; and, secondly, given that a standard based on electronic money may stand as an excellent proxy of a metallic one, looking forward, the findings may be quite relevant to emerging developments in this direction.

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