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Nicolaus Copernicus as a monetary economist

Abstract

The aim of this article is to attempt to answer the question of what Copernicus' contribution is to the formulation of the quantity theory of money. In order to achieve this goal, the definitions of the quantity theory of money were examined and the views that Copernicus had on monetary issues were analyzed. In the existing literature, there is no reference of Copernicus' concept to a specific version of the quantity theory of money, which has evolved over centuries, gaining its supporters and opponents. By the method of rational reconstructions, Copernicus' thought was translated into the field of modern economic theory. Rational reconstructions introduce the contemporary perception of the issues raised by past authors [Marcuzzo, 2008, p. 107]. The article shows that, contrary to the views that Copernicus was not the originator of the quantity theory of money, in fact, he laid the foundations for it, emphasizing the impact of the increase in the number of poor quality coins in circulation on the increase in the general price level. Copernicus' approach to the value of money is universal, although hundreds of years have passed and breakthrough technological changes have been made.

It is believed that the original version of this theory was formulated by David Hume in relation to inflation caused by the influx of precious metals from America to Europe in the years 1560–1650. The astronomer did not live to see this phenomenon; however, he was fully aware of the impact of the increase in the amount of money in circulation on prices, not only as a result of its debasement by increasing the copper content in it. This means that the form of money is irrelevant from the point of view of the concern for a stable price level, as it is important to control its supply in such a way that it is conducive to the product growth.

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The most valuable achievements of the theory of money
mostly refer to specific issues (…),
its development is stimulated
by specific events, specific experience
of the time the author lived in.

[Hicks, 1988, p. 87]

Introduction

The study of theories created in the past is burdened with the risk of being accused of dealing with outdated things, devoid of connection with the challenges of the present. According to Nobel Prize winner John Hicks, his contribution to the science of economics consisted in reaching for old theories in relation to the experiments that gave rise to them, and then comparing these experiences with the current determinants. In his opinion, there is a lot to learn from these theories, however, we must first see what they really are [Hicks, 1988, p. 89]. This article is intended to show what Nicolaus Copernicus' (1473–1543) theory of money really is.

Money has evolved, and so has the economy and the economic theory, whose authors try to keep up with the changing reality. Although economics was born with the publication of Adam Smith's *The Wealth of Nations* in 1776, Copernicus had already created the first theory of money, witnessing the debasement of coinage and rapid socio-economic changes. Geographical discoveries, a widespread use of the printing press and the Reformation gave rise to modern science, which at that moment began to refer to experience as a criterion for seeking the truth. For Copernicus, experience was a "teacher of life" not only in the sphere of his astronomical investigations, but also in the sphere of monetary issues. He focused on the practical aspects of coins in circulation, including primarily the problem of the aforementioned debasement of money, i.e. reducing the content of precious metal in coins with a fixed denomination, thanks to which it was possible to increase their number in circulation. Until Copernicus (in Antiquity and the Middle Ages), monetary issues had been the subject of ethical and legal considerations, so his view at them from the perspective of experience ends with moralizing of philosophers regarding the role of money in the economy [Bochenek, 2017, p. 712].

Since the 1970s, with the collapse of the Bretton Woods System which maintained the last link between money and gold through the convertibility of the international currency (the dollar) into bullion, it has been believed that the problem of acquiring money has lost its importance in the face of uncertainty about its value in the future [Galbraith, 2011, p. 24]. It would seem that bullion money, as in the time of Copernicus, or at least a banknote convertible into bullion, is a guarantee of maintaining the purchasing power of money, however, history shows how illusory this belief may be. The price revolution that took place in the sixteenth century is a striking example of the influence of the quantity of money in circulation on the

general price level. In the period of 1530–1660, its level in Europe increased about fourfold as a result of the influx of ores from America [Edo, Melitz, 2019, p. 7]. But inflation had already been experienced in the Old Continent before. The supply of coins depended not only on the boundaries set by nature, but also on the boundaries of greed of the monetary authorities personified by kings. Increasing the amount of money in circulation to finance government spending was known even in Antiquity,[1] but it was not until the first decades of the 16th century that Copernicus formulated the original version of the quantity theory of money, showing the relationship between changes in the money supply and the general price level.

There is rarely a need to explain who Copernicus was, because his achievements in the field of astronomy are widely known. Much has also been written about the versatility of the interests of this outstanding scholar, who, as a man of Renaissance, explored numerous issues, including mathematics and medicine. However, he is less often associated with the economic theory.

The aim of this article is to attempt to answer the question of what Copernicus' contribution to the quantity theory of money (QTM) consists in. In order to achieve this goal, it is necessary to find out how the quantity theory of money is defined and what views Copernicus had on monetary issues. In the existing literature, there is no reference of Copernicus' concept to a specific version of QTM, which has evolved over the centuries, gaining its supporters as well as opponents.

An attempt to answer this question is an important step towards assessing the importance of the Polish scholar's contribution to the development of the theory of money. It will also show some universal elements in the perception of the idea of money held by people living in different epochs, enabling the contemporary man to place current monetary issues in a broader context. Does the form of money matter? This is a key question, although beyond the scope of this article, in the current debate about digital money, constantly accompanying its creation.[2]

Money has been an institution linked to the state for centuries, so most discussions around its role in the economy inevitably refer to the situation of a particular country [Hicks, 1988, p. 89]. Therefore, in the first place, an attempt was made to outline the political and economic situation in which Copernicus was supposed to work. On the one hand, he had a practical problem to solve (proposing a monetary reform), and on the other hand, he had to act extremely cautiously in a hostile environment.

[1] Romans increased the number of coins in circulation at the expense of reducing the silver content to finance war expenses, which translated into inflation. The situation is illustrated by the need to increase soldiers' wages: a soldier's wage in 46 BCE was 225 denarii, in the years 193–211 CE 600 denarii, respectively, and in the years 235–238 already 1800 denarii [Eagleton, Williams, 2007, p. 54].

[2] The search for an alternative to fiat money was primarily driven by the policy of negative interest rates after the 2008 crisis and the technological progress conducive to the development of cryptocurrencies [Kowalewski, 2022, p. 374].

Copernicus' anxiety

There is a rich literature on Copernicus' biography[3] that could be used for detailed contextual analysis, a method often used in the history of economic thought to show the impact of the conditions in which scientists lived on their theories, but this is not the aim of this article. However, it is impossible to disregard completely the historical context when examining their work. In order not to duplicate the content concerning the details of Copernicus' life, it is worth getting to know him as a man of his time, full of fears related to the beliefs declared by him, which is illustrated by these words: "It is of no small importance to be able to shed some light on matters which are by their nature overwhelmed by a thick fog, when it may even happen that someone feels he is right, but he cannot express what he feels, I am afraid that something similar sometimes happens to me" [Kopernik, 1923b, p. 89].

The above quotation shows that an accurate assessment of reality does not always accompany the possibility of its public declaration. Paradoxically, Copernicus was not afraid to admit to the fear that limited his courage to reveal controversial beliefs. The scholar's fears were not unfounded in the face of the political situation of the time and because of his personal life and the lives of his friends around him.

The times in which the scholar lived abounded in cultural changes related to the Reformation, eradicated by the Catholic Church, which was losing its influence. In the fourteenth century in Prussia education began to develop, contributing to the popularization of the art of reading and writing among merchants, craftsmen and noblemen, and in the fifteenth century, the process of secularization of schools began, which was reflected in the takeover of their management by city councils [Nowak, 2013, p. 24]. The transformation of the people of the Middle Ages, consisting in questioning the authority of the Church hierarchy, gave rise to changes in their lifestyle: salvation related activities were replaced by focusing on earthly life and the accumulation of savings that gave rise to investment [Pawnik, 2008, pp. 23–44]. Thus, Copernicus witnessed the birth of capitalism, whose key figures were merchants, the social group from which he came himself. It was treated with suspicion by the Church, because due to its mobility it threatened the durability of the feudal system. Merchants changed the situation of craftsmen, who, until the commercial revolution begun in the 10th century, lived like ancient slaves deprived of any opportunity to raise their material status through work [Lopez, 1976, p. 123]. Merchants had capital, credit, and the ability to study the demand for handicrafts, opening new markets independent of feudal lords [Lopez, 1976, 124].[4] The social revolution, manifested in the struggle of the townsmen for their rights, was inevitably

[3] See: e.g. A. Markuszewska (Ed.). (2013). *Nicolaus Copernicus and His Times*. Toruń: Nicolaus Copernicus University Press.

[4] "No prejudice distanced merchants from craftsmen, because many, if not all, of them came from this environment, and the struggle for the liberation of cities from feudal control had been their common cause since at least the turn of the 12th century" [Lopez, 1976, p. 124].

approaching, giving hope for the improvement of the lives of people who made a living from work and not from the privilege of birth.

The political situation of Copernicus' economically developing homeland (Royal Prussia) was complicated. Royal Prussia became a district incorporated into the Polish state as a result of the Peace of Toruń in 1466; it included Gdańsk Pomerania, the Chełmno Land, Powiśle with Elbląg and Malbork, and Warmia [Nowak, 2013, p. 17].[5] The affiliation of these lands to the Kingdom of Poland was crucial from the point of view of Prussian merchants, who gained a chance to develop trade blocked by Ducal Prussia.

In the years 1519–1521, Grand Master Albrecht Hohenzollern waged a war against the Kingdom of Poland in order to annex Royal Prussia to Ducal Prussia [Małłek, 1976, p. 13]. The Teutonic Wars forced Royal Prussia, which resisted the Reformation, to seek protection from the Polish king Sigismund I the Old. The king, however, was under the influence of his ruthless wife,[6] who was accused of poisoning Prince Janusz Mazowiecki [Skodlarski, 2006, p. 118], thanks to which in 1526 Masovia was incorporated into Poland. The king also fought fiercely with the supporters of the Reformation,[7] so any criticism of the Church doctrine could have serious consequences.

These conditions had an impact on Copernicus, who fell victim to the revenge of Queen Bona's protégé, clergyman and writer Johannes Dantiscus [Skodlarski, 2006, p. 116]. He resented Copernicus for not helping him to take over the lucrative canonry of the late Andrew Copernicus. In retaliation, he decided to force Nicholaus to stop contact with his "harlot," i.e. a wealthy bourgeois, Anna Schilling, who had the courage to live with him in a relationship without marriage [Borawska, 2023, p. 549]. However, interference in Copernicus' personal affairs was not enough for the vindictive priest. He also decided to forbid the astronomer to be friends with Alexander Scultetus, who was accused, like Copernicus, of having a relationship with his landlady. In fact, Dantiscus' scandal was not caused by moral issues, but by the assumption of the canonry in 1518 by the astronomer's friend to succeed the aforementioned Andrew Copernicus [Borawska, 2023, pp. 534–549]. So, Copernicus lived in a world in which the Catholic Church, through its functionaries, used moral issues to terrorise actual

[5] "The inhabitants of these lands, who were ethnically of Polish, German, and Old Prussian origin, were commonly called *Prussians*. Regardless of the language they spoke, they felt closely connected to their own *country* (i.e. Royal Prussia) as their closest homeland. A similar local patriotism was characteristic of the inhabitants of other Polish districts, e.g. Masovia. After all, it did not exclude the feeling of political belonging to the Polish Crown. The inhabitants of Royal Prussia considered themselves loyal subjects of the Polish king, which Nicolaus Copernicus emphasised in a letter to Sigismund the Old (1520) when the Teutonic army threatened Olsztyn" [Nowak, 2013, p. 18].

[6] The king's wife, Bona Sforza, went down in history as an efficient politician and patron of culture in Poland. However, it also had a dark side. "Bona Sworza was well aware of the politics and methods of government of Italian princes, often carried out with the help of corruption and intrigue. Bona brought to Poland a style of government that was alien to the Polish political tradition. It can be said that politics and intrigues were her passion, which often caused negative effects in solving current state problems (…) It exerted influence on the decisions of Sigismund I, relying on its own political coterie. She conferred high offices and numerous estates on her confidants. Bona Sforza had unlimited power. She introduced those magnates to the Senate who were submissive to her will, and she also took control of the Chamber of Deputies" [Skodlarski, 2006, pp. 117–118].

[7] A friend of Copernicus, Tiedmann Giese, in 1525, expressed the view shared by the astronomer that Catholics should argue with Protestants and ask them to change their views instead of burning alive as the Polish king did in Danzig [Armitage, 1963, p. 89].

and potential opponents, which, contrary to the intentions of the clergy, fostered the spirit of the Reformation.

The progressing Reformation in Prussia and Poland made Copernicus increasingly lonely. In calling for Christian unity, he tried to avoid taking an unequivocal position and was distinguished by his tolerance of both Catholics and Protestants [Armitage, 1963, pp. 87–90]. As mentioned before, Copernicus worked and was friends with the opponents of Dantiscus, who took revenge on them when he became the bishop of Warmia in 1538. They were Georg Rheticus and the aforementioned Aleksader Scultetus. Dantiscus was clearly bothered by Copernicus' sympathy for Protestant scholar Georg Rheticus, who sought to publish an astronomical work *On the Revolutions of the Celestial Spheres* [Armitage, 1963, p. 91]. The cooperation with Scultetus, considered an atheist and heretic, worsened the astronomer's situation and increased his fears of publishing his work.[8]

It should be borne in mind that the outgoing Middle Ages left strong connections between the structures of the Church and secular institutions, and its influences included besides the aforementioned political also the economic sphere [Pawnik, 2008, p. 77]. The total institution, which for centuries shaped the lives of individuals and nations, imposing its system of values, was finally to give some space to free thought. This would not have been possible without the technological breakthrough in the way it was spread.

Over five hundred years ago, a revolution in the perception of the world took place as a result of geographical discoveries and the facilitation of the flow of information thanks to the popularization of the printing press. Around 1500, it was already used in 220 places in Europe [Maddison, 2007, p. 313]. The era of the fight against illiteracy began, which laid the foundations for the development of modern science, and in the following centuries also industry. From the point of view of monetary turnover, the printing press made it possible, at the turn of the 16th century, to distribute "leaflets" with images of coins accepted in circulation and coins with a good international reputation [Gierson, 1971, pp. 45–46]. The growing role of foreign trade and the related need for a "certain" medium of exchange was noticeable, which shows the universality of the search for international money.[9]

The problem of counterfeiting coins was so common in Europe that new inventions were used to combat it. Unfortunately, illiteracy made this task difficult. However, socio-economic changes took place, despite the fact that they took place in the shadow of wars and crises related to their financing. This was also the case in Copernicus' homeland.

[8] "On 13 August 1538, Scultetus assured Johannes Dantiscus that he had never married his cook and accused Hosius of Cordoba of spreading slander, but the impatient bishop demanded that he dismiss his concubine with children. Soon after, he commissioned ailing custodian Feliks Reich to prepare a formal canonical process against Scultetus, Niederhof and Copernicus, and ordered their housewives to leave the cathedral hill" [Borawska, 2024, p. 547].

[9] In fact, from Antiquity to the Middle Ages to the Modern Age, there were currencies that served as international money. Such a role was played, for example, by the Venetian ducat issued since 1284, which had to compete against the Hungarian ducat in 1325 [Hagen-Jahnke, Walburg, 1985, pp. 12–14]. In Copernicus' time, in Central Europe gold ducats, guilders, and silver thalers were commonly accepted coins in international trade [Vorel, 2022, p. 287]. Hungarian ducats were the most trusted coins due to their high gold content. Copernicus considered them as a model for other coins.

The issue of money losing its value raised concerns among the emancipating townsmen about the future of the dynamically developing trade. Copernicus' interest in monetary issues resulted from the practical needs of the monetary system of Royal Prussia and the Kingdom of Poland, which were struggling with the problem of "bad" money, e.g. through the excessive issuance of coins by Ducal Prussia. They minted worse and worse coins during the war of 1519–1521, flooding Royal Prussia with it, but the most serious problem was the influx of false Świdnica coins of Ludwik Jagiellończyk to the Kingdom [Małłek, 1976, p. 40].

The half-grosz coins of the King of Bohemia and Hungary resembled the coins of Sigismund I the Old (on the obverse there was an eagle with a crown, and on the reverse there was a crown, as on Sigismund's coins). The only difference between them was in the legend (Louis II King of Hungary and Bohemia/City of Świdnica), which in the era of the aforementioned widespread illiteracy did not cause difficulties in trading in counterfeit coins. The development of trade contributed to the rapid influx of the Świdnica half-grosz to the Kingdom of Poland, and at the same time carrying away the Crown half-grosz and minting into a worse coin, which returned to the country. This phenomenon is now referred to as the Copernicus-Gresham law, according to which a worse coin displaces a better coin from circulation.[10] This resulted in a decrease in the Crown income, inflation and a decrease in confidence in the Polish coin, to lead to a financial collapse of the Kingdom of Poland [Wlizło, Jagła, Wojnowska, 2022, p. 362][11]. The similarity of the counterfeit coins to the Crown half-grosz is illustrated by the photos below.

Figure 1. Crown half-grosz of Sigismund I the Old from 1507–1511

Source: Wlizło, Jagła, Wojnowska, 2022.

[10] "How much more erroneous it was to combine the old, better coin left in circulation with a new, worse coin, which not only infected the old one, but, so to speak, drove it out of circulation" [Kopernik, 1923a, p.59].

[11] Ludwik Decius, secretary of King Sigismund I the Old, wrote about the Świdnica coin in the following way: "The coin of Świdnica, harmful to everyone, which imitates the coin of two kings in such a way that not only the common people, but even the merchants cannot recognise it" [Decius, 1923, p. 146].

Figure 2. Świdnica half-grosz from 1521–1526

Source: Wlizło, Jagła, Wojnowska, 2022.

The defectiveness of the monetary systems of Royal Prussia and the Kingdom of Poland required urgent reforms, which could only be proposed by scholars recognized as specialists in the field of finance at the time. In 1517, Copernicus wrote at the request of Bishop Fabian Luziański *Meditations* on the Monetary Problems of Royal Prussia [Bochenek, 2017, p. 700]. It was the first work in which Copernicus deliberated on the idea of money and its role in the economy. Subsequent works were commissioned by King Sigismund I the Old[12] in 1519–1528 and it is in them that researchers look for the beginnings of the quantity theory of money. In order to find out what Copernicus' contribution to this theory consisted in, it is necessary to refer to its definitions and forms that are an appropriate reference point for Copernicus' concept.

The idea of the quantity theory of money

The quantity theory of money (QTM) has been controversial since it was challenged by John Maynard Keynes in the 1930s, which he did while negating Say's law[13] perceived by him in a specific way. In the simplest terms, according to QTM, the general price level is determined by the amount of money in circulation, however, this theory evolved over the centuries since it was formulated [Polanski, 1987, p. 1284]. Despite Milton Friedman's modification of QTM in the 1950s in response to a Keynesian challenge, researchers continue to question its

[12] The king also commissioned this task to Louis Decius, whose reform was eventually implemented, with slight modifications, to include Copernicus' comments.

[13] According to Keynes, Say's law is a statement that supply creates demand for itself in such a way that all costs of production (wages of production factors) are allocated to the purchase of the manufactured product, which is possible when people do not store savings in the form of cash [Korczyk, pp. 16, 106]. Thus, without reference to the *Treatise on Political Economy*, Jean Baptiste Say created a vision of an unrealistic law about automatic rebalancing by the market mechanism. In fact, Say described in detail the causes of the crises.

explanatory value.[14] There is no doubt, though, that they agree on the existence of a connection between changes in the quantity of money and its purchasing power.

According to Friedman, the founder of monetarism[15] including the modern version of QTM (1956), the first formal formulation of this theory is the words of Hume from 1752 [Friedman, 1989, pp. 1–2]. He also started his article entitled *Quantity Theory of Money* with them, thanks to which the reader gets acquainted with the idea of the theory at the beginning.[16] It boils down to emphasizing a long-term neutrality of money and its short-term impact on real quantities.

The events of the time that influenced Hume's considerations of money are unknown, but he certainly drew on historical works on the influx of silver from America to Europe between 1560 and 1650, which resulted in rising prices [Hicks, 1988, p. 92]. Therefore, he took into account a period later than the one in which Copernicus lived, observing inflation caused by the debasement of coinage by reducing the content of precious metals in it. Thus, for the development of Hume's classical theory of the quantity of money, the key event was the increase in the amount of money in circulation caused by the increased gold stocks, and not by its debasement by the monetary authorities, although Hume also referred to this phenomenon. Therefore, the money supply was an exogenous factor determined by the forces of nature [Hicks, 1988, p. 93].

According to Hume, an increase in the amount of money in circulation raises the prices of labour and goods, but before this happens, during the transitional period a larger amount of money stimulates industry.[17] A proper monetary policy should, therefore, focus on increasing the money supply gradually (e.g. by dividing coins into smaller ones) so that it is suitable for handling exchange in conditions of increased production. Hume even accepted the aforementioned debasement of money by reducing the amount of precious metals in coins.[18] Hume's fear of insufficient amount money in circulation for the development of industry prevailed over his concern for preserving its purchasing power. This results from the above-mentioned

[14] See: P. Teles, H. Uhlig, (2013, Nov). Is Quantity Theory Still Alive? *European Central Bank Working Papiers Series,* 1065.

[15] It is important to distinguish monetarism from monetary economics because monetarism is one of the theories of money within the neoclassical paradigm, while monetary economics is a branch of economics that encompasses various theories of money.

[16] "Lowness of interest is generally ascribed to plenty of money. But (…) augmentation [in the quantity of money] has no other effect than to heighten the price of labour and commodities (…) In the progress toward these changes, the augmentation may have some influence, by exciting industry, but after the prices are settled (…) it has no manner of influence. Though the high price of commodities be a necessary consequence of the increase of gold and silver, yet it follows not immediately upon that increase; but some time is required before the money circulates through the whole state (…) In my opinion, it is only in this interval of intermediate situation, between the acquisition of money and rise of prices, that the increasing quantity of gold and silver is favourable to industry (…) We may conclude that it is of no manner of consequence, with regard to the domestic happiness of a state, whether money be in greater or less quantity. The good policy of the magistrate consists only in keeping it, if possible, still increasing (…)" [Hume, 1752, after: Friedman, 1989].

[17] Therefore, there is not always a threat of inflation.

[18] "These admit of divisions and subdivisions to a great extent; and where the pieces might become so small as to be in danger of being lost, it is easy to mix the gold or silver with a baser metal as is practised in some countries of Europe; and by that means raise the pieces to a bulk more sensible and convenient" [Hume 1752, p. 52].

belief of the scholar about the short-term impact of money on production and employment, which can be reduced as a result of insufficient amount of the medium of exchange. As already said, its gradual increase (e.g. by debasement of coinage) makes these quantities grow.

"It seems a maxim almost self-evident, that the prices of everything depend on the proportion between commodities and money (…). Increase the commodities, they become cheaper; increase the money, they rise in their value. As, on the other hand, a diminution of the former, and that of the latter, have contrary tendencies" [Hume, 1752, p. 52]. These words allow us to present the dependence of the general price level (P) on the quantity of money in circulation (M) and the volume of production (Q) in the form of a simple equation:

$$P = \frac{M}{Q}.$$

In order to properly interpret Hume's explanation of how P changes, it is necessary to take into account some of the limitations he introduced. Namely, it is not the total resources of M and Q that determine P, but the amount of M in circulation (not in vaults) and Q that goes to the market.[19] It can be considered the beginnings of the concept of the velocity of money, but Hume was not clear on this point, so QTM had to wait for Irving Fisher to introduce this quantity into his equation of exchange.

Emphasizing a short-run impact of changes in the money supply on real factors (production and employment) is a key element of the twentieth-century QTM as the heir to Hume's thought. QTM lost this element in the nineteenth century. It happened as a result of modifications introduced by classical economists, such as John Stuart Mill, who believed that changes in the quantity of money in circulation cause only proportional changes in the general price level [Korczyk, 2019, p. 90].

The author of the neoclassical version of QTM is considered to be the aforementioned American economist Irving Fisher. He formulated it in 1911, emphasizing that the price level is a function of the amount of money in circulation [Bartkowiak, 2019, pp. 130–131]. It can be assumed that if money is of a metallic nature (as in the time of Copernicus and Hume), then its supply should be treated as an exogenous variable [Hicks, 1988, p. 105]. However, this is a simplified approach, as it will turn out later in the article, because the debasement of bullion money makes it possible to increase its amount in circulation regardless of the resources of precious metals. Leaving aside this aspect of money creation in the bullion system, in the case of an economy with "hard" money and underdeveloped financial system,[20] QTM in the form

[19] "It is also evident, that the prices do not so much depend on the absolute quantity of commodities and that of money, which are in a nation, as on that of the commodities, which come or may come to market, and of the money which circulates. If the coin be locked up in chests, it is the same thing with regard to prices, as if it were annihilated; if the commodities be hoarded in magazines and granaries, a like effect follows. As the money and commodities, in these cases, never meet, they cannot affect each other" [Hume, 1752, p. 53].

[20] Not without significance for understanding Copernicus' thought about money is its form and the financial system of the time, which differed from the gold standard system in Fisher's time, and Fisher's approach was more adequate to describe Copernicus' monetary reality than his own, when the bank money (created by granting loans) was already in operation. It is necessary to distinguish between ordinary credit transactions within the operation

of the MV=PQ exchange equation is appropriate to describe it [Hicks, 1988, p. 122]. Therefore, it is justified to call it the theory of the general price level [Laidler, 1991, p. 84].

Fisher's equation of exchange shows[21] that the general price level is formed as follows:

$$P = \frac{MV}{Q}.$$

The price level of products (P) depends on the amount of money in circulation (M), which is treated as an exogenous factor, on the velocity of money circulation (V) and the volume of transactions (Q). The question of the velocity of money circulation remained outside the realm of considerations made by both Hume and Copernicus, while Fisher treated it as a factor (approximately constant) dependent for instance on saving habits, population density, attitude to consumption or the use of cheques [Korczyk, 2019, pp. 92–93]. Certainly, the differences in the conditions in which scholars lived influenced the fact that it was not until the twentieth century that the issue of the velocity of money circulation became important.

Copernicus attached great importance to the monetary function of the store of value, which Fisher took into account as one of the factors shaping V. There is a lack of the category of demand for money in his theory, and Friedman mentioned it when analyzing the weaknesses of the existing forms of QTM. The demand for money is of key importance in Copernicus' monetary thought, covering both the issue of the impact of the amount of money in circulation on price rises as well as the law of displacing better money from circulation by worse money (the Copernicus-Gresham law).[22]

It may be said that QTM defined by Arthur Cecil Pigou in the first decades of the twentieth century contains this component of Copernicus' thought. Pigou's theory boils down to a generalization indicating that changes in the real amount of money desired by people[23] (changes in the demand for money) occur slowly as a result of changes in the supply of goods and services, while changes in the nominal amount of money can and often do occur regardless of the amount of demand for money [Friedman, 1989, pp. 3–4]. This happens when the

of bullion coin and an organised banking system [Abbot, 1934, p. 399]. An interest-bearing or interest-free loan of bullion money was merely a transfer of purchasing power from one entity to another, but it did not create purchasing power [Abbot, 1934, p. 400]. Only when the deposits at the disposal of their owners become at the same time the basis for granting loans constituting purchasing power, can we speak of bank money.

[21] MV=PQ, where M is the amount of money in circulation, V is the velocity of money circulation, P is the price index, Q is the volume of transactions [Niehans, 1994, p. 227].

[22] The demand for better money causes it to be pushed out of circulation, which Copernicus wrote about in the context of goldsmiths in possession of information [Kopernik, 1923a, p. 62].

[23] As Friedman emphasized, the key to understanding QTM is the distinction between the nominal quantity of money and the real quantity of money. The first is the quantity of money expressed in any unit, e.g. the dollar (there are doubts as to what assets can be included in it), while the second includes the volume of production that this money allows to be purchased [Friedman, 1989, pp. 1–2]. The issue of nominal quantity is related to the evolution of forms of money, so Friedman postulated treating equivalents adequate to place and time as money. Clarity in this matter is necessary because the determination of the real quantity depends on the accepted definition of the nominal quantity: one way to calculate the real quantity is to divide the nominal quantity by the price index, with the real quantity being the most important for the owners of money [Friedman, 1989, p. 3]. It determines the ability to meet people's needs.

monetary authorities increase the money supply, e.g. by debasing money, as in the time of Copernicus. This phenomenon results in inflation, whose negative effects economists focus on.

Therefore, the Pigou equation relates the demand for money to the product, price level, and savings factor [Bartkowiak, 2019, p. 132]. The version of the equation quoted below omits banknotes and demand deposits, which were not widely used in Copernicus' time[24] [Korczyk, 2019, p. 97]:

$$P' = \frac{kQ}{M}.$$

where:
P' – the price of money expressed in product (purchasing power);
Q – product volume;
k – share of the product stored in the form of money;
M – the amount of money in circulation.

The quoted equation shows that an increase in the money supply (with other factors remaining unchanged) contributes to a decrease in the purchasing power of money, and vice versa: an increase in production (Q) and the propensity to store savings in cash (k) affect the increase in demand for money, and thus its exchange value (purchasing power).

Although Pigou defined coefficient k as the inverse of V (k=1/V), looking at k simply as the share of the product (Q) stored in money is more reasonable. Especially since among the factors shaping the k level, Pigou mentioned convenience and security that result from having cash, the possibility of an alternative use of cash for production purposes, i.e. investment opportunities which bring profits, and consumption needs [Pigou, 1917, p. 44]. These factors are not the same as the factors mentioned by Fisher regarding the determination of V. It is important in particular because Fisher believed that consumption on credit accelerates V [Fisher, 1911, pp. 81–82], which in no way translates into the k-factor concerning cash.

Pigou's theory implies that an increase in money supply should result from the product growth (it translates into a demand for money), and if the state increases its amount in circulation with a constant volume of production, it will lead to an increase in the prices of goods [Bartkowiak, 2019, p. 134]. The demand for money generated by production (Q) results from the function of money as a medium of exchange, while the demand manifested in the coefficient k results from the store of value function. Using Pigou's theory, it is possible to shed some light on the idea of Copernicus' concept, taking into account not only his considerations on the influence of the quantity of money in circulation on the price level, but also the law of displacing better money by worse.

[24] The creation of money by banks through deposits in such a way that they do not deprive the depositor of the possibility of using the deposited funds while allowing the borrower to make payments, has been known since the 15th century, but deposits were accepted occasionally and there was no organized banking activity [Abbott, 1934, pp. 400–404].

Copernicus to guard the value of money

At the beginning of the analysis of Copernicus' views on monetary issues, it should be emphasized that he did not identify the coin with silver or gold. It is very easy to fall into the trap of thinking about the sixteenth-century monetary system as one in which precious metals in their pure form served as a medium of exchange. Although the coins did indeed contain silver or gold, there was always an admixture of copper in them (for example for practical reasons). Thus, for Copernicus, the coin was marked gold or silver serving as a means of payment, referred to as money, as an institution closely linked to the state, which with its seal guaranteed public confidence [Kopernik, 1526, pp. 55–56]. Trusted money facilitated transactions, as it was no longer necessary to weigh the bullion.

However, the coin was not crucial to the existence of trade. According to Copernicus, it could only be done with silver and gold, which were generally valued and accepted, but the convenience of abandoning the use of scales for each transaction contributed to the marking of coins [Kopernik, 1526, p. 56]. Therefore, gold was also money, but of a different kind, because it played the role of primarily a store of value and a measure of value. Ultimately, according to Copernicus, merchants and craftsmen, when selling their goods, took into account the amount of gold and silver they wanted to receive for them, i.e. the lower the content of precious metals in coins, the greater the amount of precious metals was allocated for payment [Kopernik, 1528, pp. 62–63].

These remarks may seem insignificant from the point of view of the differences between the current monetary system (based on fiat money) and the system of Copernicus' time, but they are of great importance from the perspective of similarities between different forms of money and the evolution of economic theory. Contrary to appearances, the operation of coins in circulation did not differ significantly from the later issuance of banknotes covered with bullion, although banknotes allowed for more economical use of silver and gold. The supply of coins and banknotes (money) was determined, on the one hand, by the availability of precious metal resources (natural constraints), and on the other hand, by the monetary policy of the issuer, who, depending on the needs (e.g. war), could finance its expenses by increasing the amount of money in circulation.

This problem concerned Ducal Prussia in the first decades of the 16th century, when it waged a war against Royal Prussia as part of the Kingdom of Poland, financing it by minting more and more coins (with less and less silver content) also flooding Royal Prussia. A similar phenomenon occurred during World War I, when the convertibility of banknotes into gold was suspended and an increasing number of them were printed without gold backing [Korczyk, 2022, p. 96]. In both cases, the result was inflation, i.e. an increase in the general price level expressed in coins or banknotes, but not in silver or gold, as was the case at the time when precious metals were flowing into Europe from America. Debased coins and banknotes allowed for the purchase of less and less precious metals and other products due to their abundance in relation to them.

The critics of the thesis that Copernicus was the precursor of the quantity theory of money believe that he did not relate too many coins in circulation (money supply) to the volume of the product, so he did not see a relationship between the increase in the supply of coins and the increase in the general price level, focusing on the lower bullion content in the coin [Volckart, 1997, p. 436]. Copernicus is believed to have created the metallic theory of money [Bochenek, 2023, p. 21]. This is also one of the arguments that appears in the Polish Marxist literature [Dunajewski, 1952, p. 229]. For example, Edward Lipiński claimed that Copernicus did not create a theory of money (QTM) incompatible with the Marxist paradigm.[25] According to Lipiński, Copernicus' statement that the coin "has a lower estimate especially due to its excessive quantity" is not a sufficient argument in favour of considering the astronomer as the precursor of QTM [Lipiński, 1956, p. 34]. Lipiński concluded that every time Copernicus spoke about the increase in the number of coins in circulation, he pointed to its debasement, i.e. the reduction in the content of bullion, which, according to Lipiński, is a factor determining the purchasing power of money [Lipiński, 1956, p. 37]. It is clear that in accordance with Marx's doctrine, Lipiński rejected the fact that it is the increase in the quantity of money that causes the increase in the general price level, regardless of what causes the increase in the number of coins (their debasement or increase in the supply of precious metals). However, he paradoxically admitted that the debasement of coins causes the fact that "the mass of money does not increase as a result of an increase in production and turnover, but comes as if from outside the production processes" [Lipiński, 1956, p. 43]. Today we would say that it is exogenous in nature. As Lipiński further noted, Copernicus considered the debasement of coins the cause of huge rises in the prices of silver, gold, and other commodities as well as craftsmen's wages [Lipiński, 1956, p. 43]. Undoubtedly, the astronomer noticed the problem of the relation of the quantity of money in circulation to the volume of production in the formation of prices. He did not focus only on the issue of the reduced amount of precious metals in coins.

In fact, Copernicus considered the problem of too many coins in circulation in two ways. On the one hand, he saw the issue of scarcity, which lies at the root of the existence of the economic problem, because needs are unlimited and resources are limited. In the context of money and its complex form (bullion and coins), Copernicus introduced the category of money estimate, interpreted by some researchers as a nominal value [Cackowski, 2013, p. 286]. However, it seems that he meant the purchasing power of coins (exchange value).[26] As Copernicus wrote, "A coin has a lower estimate especially due to its excessive quantity,

[25] Marx took the position that QTM was wrong in view of theory of value based on labour, which he also applied to money. "The illusion that it is (…) prices which are determined by the quantity of the circulating medium, and that the latter for its part depends on the amount of monetary material which happens to be present in a country, has its roots in the absurd hypothesis adopted by the original representatives of this view that commodities enter into the process of circulation without a price, and that money enters without a value, and that, once they have entered circulation, an aliquot part of the medley of commodities is exchanged for an aliquot part of the heap of precious metals" [Marx, 1951, p. 130].

[26] In the Latin version of Copernicus' writings, the word "estimation" appears, which in the Middle Ages was understood as the price of a good sold on the market, therefore, in the light of Copernicus' other considerations, it should be assumed that his "estimate" is the exchange value of money, i.e. purchasing power [Volckart, 1997, p. 437].

namely; if so much silver were minted into coins that people would seek silver in bullion rather than coin, for in this way the significance of the coin is lost, because it cannot buy as much gold or silver as it contains" [Kopernik, 1526, p. 56]. These words show that even if the coin was not debased, i.e. the share of precious metal in the coin did not decrease, but only its amount in circulation would increase, the purchasing power of the coin in relation to the bullion would decrease because people desire rare things.[27]

On the other hand, Copernicus expressed his conviction, which Lipiński referred to, that too many coins in circulation cause an increase in the general price level. This is evidenced by the following quotation: "Hence arise the general and incessant complaints that gold, silver, food, domestics' wages, artisans' labour and everything else in the use of men are ordinarily exceeding the price, but heedlessly, we do not suspect that this general dearness is due to the degradation of money" [Kopernik, 1526, p. 62]. Such an approach to the issue can also be found in the later work of Hume.

This problem may be seen from the perspective of the demand for money. The debasement of coins led not only to their higher quantity (M), but also to a decrease in the k-factor, thus decreasing their purchasing power (P'). The desire to store part of the product in such money was on the decline, leading at the same time to a higher demand for gold and silver as a store of value[28] under the Copernicus-Gresham law. Undoubtedly, Copernicus can be considered a precursor of QTM.

Moreover, Copernicus considered products that meet people's needs, not money (both coins and bullion), to be the true wealth of a country, before mercantilism identified wealth with money, becoming a doctrine opposed only by the physiocrats and classics in the eighteenth century.[29] According to Copernicus, money was to serve the real economy, which allows us to think of it as a precursor of classical economics, and not just QTM: "It is also known that the countries in which good coins circulate have works of art, excellent craftsmen and everything in abundance (…)" [Kopernik, 1526, p. 63]. Copernicus' innovativeness is particularly visible when it is related to the way wealth was understood by the Polish society of the time. The deputies, being part of it, expressed in the statute of the Sejm in Radom (1505) the view that the accumulation of gold contributes to the multiplication of wealth [Zagóra-Jonszta, 2013, p. 67].[30]

[27] Copernicus also wrote that" (…) the estimate of the coin itself depends on the quality of the material, but the value of the coin must be distinguished from its estimate, since a coin can be valued higher than the material of which it is made, and vice versa" [Kopernik, 1526, pp. 55–56].

[28] It should be emphasized that in Copernicus' time, the importance of hoarding allowing for investments was growing, which is why it was crucial to maintain a constant value of monetary capital, i.e. money with unchanged purchasing power [Zagóra-Jonszta, 2013, p. 68].

[29] Hume perceived the idea of wealth in a similar way: "…wherever a sovereign has a number of subjects, and has plenty of commodities, he should, of course, be great and powerful, and they should be rich and happy, independent of the greater or lesser abundance of precious metals" [Hume, 1752, p. 52].

[30] In the era of geographical discoveries and the growing importance of merchants throughout Europe, the view that getting rich is the overriding goal of human activity began to dominate, and by getting rich it was understood as the accumulation of precious metals [Zagóra-Jonszta, 2013, p. 74].

Therefore, the shape of the reform of the monetary system proposed by Copernicus, but not fully implemented by King Sigismund I the Old, is not surprising. The reform was to promote the introduction of money with stable purchasing power into circulation, which was primarily to be achieved by avoiding "too many coins" [Kopernik, 1526, p. 69]. Copernicus was in favour of the creation of a single mint for the entire Kingdom, which was to control the money supply, as well as to get rid of the king's right to finance his expenses by issuing coins. This was not a practice used only by Sigismund I the Old. The rulers of the time established it as a permanent element of the fiscal policy [Lipiński, 1956, p. 31]. This means that Copernicus, in his intention of reform, was also a precursor of the concept of independence of monetary policy (implemented today by central banks) from fiscal policy (which today belongs to the government). It was decided to implement a worse reform project by Decius, who did not agree to the king's resignation from fiscal profits from minting coins [Zagóra-Jonszta, 2013, p. 74].

Summary

Copernicus laid the foundations for QTM, emphasizing the impact of the increase in the amount of poor quality coins in circulation on the increase in the general price level. Copernicus' approach to the value of money is universal, despite the passage of hundreds of years as well as technological changes. According to the subject literature, the original version of this theory was formulated by Hume in relation to inflation caused by the inflow of precious metals from America to Europe in the years 1560–1650 [Hicks, 1988, p. 92]. Although the astronomer did not live to see this phenomenon, he was aware of the impact of the increase in the amount of money in circulation on prices, not only as a result of its debasement by increasing the copper content in it. This means that the form of money is irrelevant from the point of view of concern for a stable price level, because it is important to control its supply in such a way that it is conducive to the product growth. It is also significant that Copernicus perceived as "real" wealth not the amount of ore that a country had, but the products that its inhabitants had, which was only noticed by Hume, physiocrats, and classical economists who broke with the doctrine of mercantilism.

Although Copernicus' three monetary treatises were published between 1517 and 1526, it is recognized that they were not known to economists until they were published by Polish French economist (with Jewish roots) Wołowski in 1864 (Bochenek, 2023, pp. 8–10). However, this does not change the fact that Copernicus' approach to monetary issues was well ahead of his time.

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