Research Article

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Iconographic Trends in Roman Imperial Coinage in the Context of Societal Changes in the Second and Third Centuries CE: A Small-Scale Test of the Affluence Hypothesis

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Abstract: This article presents a quantitative analysis of iconographic trends in the depiction of deities in the coinage of the Roman Empire throughout the second and third centuries CE to explore temporal shifts in Roman imperial propaganda in the context of developments and pressures in affluence, prosperity, and political stability. Next to providing deeper insight into the topic of Roman imperial ideology, the article's main objective is to test the validity of the so-called affluence hypothesis from the debate on cultural evolution. The hypothesis predicts that an increase in affluence and prosperity leads to the emergence of moralizing themes in religion. Based on the comparison of the iconographic trends in Roman coinage, as represented by the Online Coins of the Roman Empire project portal of coin types, with changes in affluence and prosperity indicators for the period of the second and third centuries CE, the results suggest that in times of political stability and prosperity, Roman Empire emphasized moralizing deities on coins more often than in times of crisis. In contrast, martial deities and those oriented on dominating power were promoted on coins more frequently in turbulent times. In this small-scale case study, the results support the arguments of the affluence hypothesis.

Keywords: Roman coinage, Roman imperial ideology, iconography, affluence hypothesis, temporal modeling

1 Introduction

Roman emperors resided at the hierarchical top of Roman society and had various channels at their disposal to voice their ideas to the population. One of these channels was the circulation of Roman coinage. While the obverse side of Roman coins most frequently depicted portraits of Roman emperors, the reverse side was a place for conveying ideological messages related to deities, promises, values, or events of importance for a particular emperor through iconography and short statements (for ideological impact of Roman coinage in circulation, see especially Hedlund, 2008; Kemmers, 2006, pp. 219–240; Manders, 2012; Metcalf, 2012; Noreña, 2011). Furthermore, because hundreds of thousands of Roman coins and tens of thousands of Roman coin types have been cataloged, it is possible to quantitatively explore iconographic trends over time in Roman coinage to reveal themes and changes in imperial ideology.
The research question associated with this goal deals with the factors that could have triggered shifts in these iconographic trends. Particularly, the study examines how the depictions of Roman deities on the reverse side of Roman coins developed and changed during the second and third centuries CE in the context of major societal pressures, such as the transition from the prosperous time of Pax Romana (ca 27 BCE to 180 CE) to the so-called Crisis of the Third Century. The study thus presents a quantitative temporal analysis of the attributes of specific deities and personifications depicted on Roman coin types in the standard reference work *Roman Imperial Coinage* (RIC) as represented by the Online Coins of the Roman Empire (OCRE) project portal (Meadows, Bagnall, Bransbourg, & Gruber, 2012). It reveals iconographic trends that, when compared with proxy data for societal pressures and development in the Roman Empire, help us understand what was imperial propaganda communicating to the population in times of stability, change, and crisis.

Finally, this article evaluates how the findings from quantitative analyses of Roman coins contribute to the discussion on the cultural evolution of moralizing religions and opens the question of “What conditions benefit the emergence of moralizing motifs in religion?” In this regard, the study tests the validity of the so-called affluence hypothesis (Baumard, Hyafil, Morris, & Boyer, 2015; Baumard & Chevallier, 2015). The affluence hypothesis suggests that the emergence and spread of moralizing religions in several independent cultural environments over the last few millennia has been caused by shifts in life history strategies in response to an increase in economic prosperity. This suggestion is based on the so-called life-history theory, a branch of evolutionary biology focusing on how organisms allocate their resources in response to environmental clues (Stearns, 1992). The life-history theory begins with an observation that each organism across its lifespan has a limited budget of resources to be allocated to maximize its reproductive success. When the resources are scarce and the risk of dying is high, it is adaptive for an organism to reproduce as soon as possible and to produce as many offspring as possible; when the environment is stable, safe, and affluent, it is adaptive to reproduce later, to have fewer offspring in total, but to turn to them with higher parental investment. In the case of human populations, it has been documented that in a harsh environment, humans tend to behave according to a “faster” strategy, to mature earlier and to have more children, while in an affluent environment, a “slower” strategy takes place (Nettle, 2009, 2010). Importantly, the continuum from “fast” to “slow” life history strategies is inter-correlated with a number of other behavioral preferences and cognitive traits. For instance, individuals growing in harsh environments tend to be more violent, less cooperative, and more presence oriented (e.g. Frankenhuysen, Panchanathan, & Nettle, 2016). In this context, the affluence hypothesis proposes that a shift toward “slower” life history strategies in a population will also cause changes in the religious domain, as modified behavioral preferences will increase the popularity of specific values, representations, and forms of behavior. These features concern (a) extended cooperation (emphasis upon altruism), (b) restricted sociosexuality (values of purity, monogamy, and asceticism), and (c) delayed gratification (belief in the afterlife) (Baumard & Chevallier, 2015). To sum up, the affluence hypothesis predicts that (1) an increase in affluence in a society will lead to the adoption of slower life history strategies by a certain proportion of the population, (2) this change in strategies will be accompanied by certain cognitive traits and behavioral preferences, and (3) these new traits and preferences will cause the emergence and thriving of new religious values, representations, and forms of behavior, for which an emphasis on extended cooperation, restricted sociosexuality, and delayed gratification is typical.

While Baumard et al. (2015) tested this prediction using macro-historical proxy data to analyze the long-term economic and demographic development of three distinct regions in Eurasia (the Yellow and Yangzi rivers in China, the Ganges Valley in India, and the eastern part of the Mediterranean), this study tests this hypothesis on a small-scale level by using a material connected to the imperial propaganda and is thus related to the elite portion of the Roman population, i.e. Roman emperors, their associates, and Roman officials in the second and third centuries CE, who most probably cooperated together on the selection of coin types (for discussion, see e.g. Levick, 1982; Manders, 2012, pp. 31–32; Suski, 2010; Wallace-Hadrill, 1986; Wolters, 2003, pp. 175–204). Although Roman emperors and the surrounding social environment forming the imperial propaganda were by no means representatives of the general population, they are a sufficiently consistent group in the context of their social position, and there are adequate amounts of available data to examine how their preferences of religious values on coinage changed based on (a) the contemporary degree of affluence and stability related to their status, and (b) reflection of contemporary sentiments of the population toward the state of affluence and prosperity in the society.
Carlos F. Noreña is one of the leading researchers in the academic debate on Roman coinage as a medium for conveying imperial sentiments, and he too approaches the topic quantitatively, although he uses the number of coins (exemplars) of individual types, rather than the number of types themselves. Throughout the last 20 years, Noreña convincingly argues that Roman coins were official documents and official representations of the Roman emperors and their virtues and ideas (Noreña, 2001, 2007, 2011). By comparing the relative frequencies of different deities and personifications on coins from the Roman Empire, Noreña noticed that early in the second century CE, there are indicators of a “discursive shift” among Roman elites toward putting emphasis on virtues, which can be attested not only by coins but also by the ancient literature (e.g. Pliny, Suetonius) (Noreña, 2001). Particularly, Noreña reveals that it was under the emperors Nerva, Trajan, and Hadrian when the imagery of Roman virtues became emphasized on coins. Noreña also follows the relative frequencies of Victoria coin types and argues that the upsurges in the number of depictions of Victoria, i.e. the goddess of victory with militaristic attributes, can be connected to the times of aggressive wars (e.g. under Marcus Aurelius) (Noreña, 2001; 2011, pp. 164–65, 240–44).

Erica Manders, another scholar active in this discussion, recognizes Noreña’s contributions to the topic and observes the changes in time in Roman coinage as well (Manders, 2012). Her identification of the “core imperial benefits” related to prosperity on coin types depicting the deities Securitas (representing security), Pax (representing peace), Felicitas (representing good luck, blessedness, or happiness), and Salus (representing well-being and good health) is highly relevant for testing the affluence hypothesis. She shows that these four imperial benefits were depicted on the coins of over 20 emperorships. However, Manders adds that it is not possible to interpret these depictions strictly as indicators of contemporary reality and argues that the Pax coin types issued in the turbulent third century CE can only be interpreted as imperial promises in times when peace was far from the emperors’ grasp (Manders, 2012, pp. 192–221).

In this article, we follow up and build on the findings of Noreña and Manders by quantitatively exploring the temporal themes in the iconography on the reverse sides of Roman coinage as represented in the OCRE project (Meadows et al., 2012), which represents over 50,000 coin types from the standard reference work for RIC and by comparing these changes against contemporary societal pressures and developments such as the assassinations of Roman emperors, changes in epigraphic habit, trends in mining, or building activity. By doing so, we were able to test the validity of specific notions proposed in the affluence hypothesis on the small-scale level of the highest Roman elites.

### 2 Materials

Iconographic motifs on the reverse side of Roman coinage offer a unique insight into the official ideology promoted by Roman emperors. Numismatic evidence from the Roman period is particularly suitable for the analysis of developments and trends in these motifs, as tens of thousands of coin types have survived in excavated coin hoards across the Roman Empire (see e.g. Howgego & Wilson, 2005). In his book, Noreña (2011) analyzed the representations of imperial ideals using a sample of approximately 185,000 coins (not coin types) minted in Rome between 69 and 235 CE from specific coin hoards. Manders (2012), on the other hand, focused on a later timeframe (193–284 CE) and explored the coin types listed in the RIC catalog, a multivolume and established corpus of Roman numismatic evidence. In alignment with the findability, accessibility, interoperability, and reuse of digital assets principles (FAIR) of open science (Wilkinson et al., 2016), the study presented here analyzes the coin types used in RIC (i.e. unique combinations of reverse and obverse sides for a specific denomination that were minted) dated to the period of the Roman Empire and included as unique entries in the representative OCRE project portal (Meadows et al., 2012), which is a digital mirror of the RIC corpus that was published in volumes over the course of the last hundred years. OCRE uses the method for defining coin types from RIC volumes as they were published and employs the vocabulary and ontology of the collaborative Nomisma project, which provides stable digital representations of numismatic concepts and is based on the linked open data principles (Heath, Meadows, & Gruber, 2010; for numismatic standards and coin iconography in the digital sphere, see also Pavlek, Winters, & Morin, 2022).
The OCRE dataset was downloaded from the Nomisma project website as a single RDF file (from http://numismatics.org/ocre/apis and the file from http://numismatics.org/ocre/nomisma.rdf) on April 6, 2023, for the purposes of quantitative analysis and contained 54,403 coin types at the time of download. The coin types listed in the OCRE dataset (i.e. single entries with a unique id in the format e.g. “http://numismatics.org/ocre/id/ric.3.ant.92”) have several attributes that allow for a detailed categorization and filtration of the data, such as the authority under which the coin was issued, type of denomination, and – most importantly for the case study presented here – the description and identification of motifs and texts on the reverse and obverse sides of a particular coin type. The date of origin of individual coins was assigned randomly within their dating interval following a uniform distribution based on the “hasStartDate” and “hasEndDate” attributes within the OCRE dataset. The majority of coin types is dated precisely, but this “random-date-within-interval” selection was chosen as the appropriate method for coin types with 5 or 10 years of uncertainty in their dating interval. The script used for data extraction and analysis is openly available at Zenodo (Glomb & Kaše, 2023).

Contrary to Noreña and Manders, we focused on a wider temporal frame in the analysis of coin types as represented in OCRE, i.e. mainly the second and third centuries CE. This selection was because this article focuses on developments in imperial ideological trends on Roman coin types in the context of societal pressures, and during the period of the second and third centuries CE, the Roman Empire faced dramatic changes spanning from the times often labeled as the Pax Romana to the so-called Crisis of the Third Century. The umbrella term Pax Romana describes a period of the first two centuries CE (ca 27 BCE to 180 CE), during which the Empire was relatively politically stable and prosperous. During the Pax Romana, the Empire reached its largest territorial extent (more specifically in the reign of Trajan, 98–117 CE), and, generally speaking, Roman emperors ruled over longer periods of time than in the third century CE. The end of the Pax Romana is usually dated to the reign of the last ruler of the Nerva-Antonine dynasty, Commodus (176–192 CE), who was eventually assassinated (for discussion, see e.g. Cornwell, 2017, p. 4; Goldsworthy, 2016; Harper, 2017, pp. 10, 25, 36, 55, 118; Woolf, 1993). In contrast to the time of the Pax Romana, the so-called Crisis of the Third Century describes the state of political turmoil and instability in the Roman Empire that followed. The third century CE is marked by a frequent succession of emperors ruling over shorter periods of time (some of them only months), a high frequency of assassinations of Roman emperors, civil wars, and invasions (Figure 1) (Christian & Elbourne, 2018; Saleh, 2019; Scarre, 1995). Thus, these two centuries defined by significant swings on the scale of the prosperity and political stability of the Roman Empire constitute an adequate segment for testing the affluence hypothesis on the Roman imperial propaganda and its reflection of these changes as represented by coinage.

Figure 1: The length of reigns (in years) of Roman emperors in the first, second, and third centuries CE with identification of the assassinated emperors.
While umbrella terms such as Pax Romana and the Crisis of the Third Century offer quick assessment and insight into the differences between the second and third centuries CE, they are too reductive and generalizing to capture the developments and changes in political stability, prosperity, or affluence in the Roman Empire in greater detail. To bring more nuance to this assessment, an overview of published quantitative data approximating the trends in prosperity, affluence, political stability, and societal pressures in the Roman Empire is presented here: animal bone data as indicators of variety in Roman diet and degree of food consumption (Jongman, 2014; King, 1999); ancient Mediterranean shipwrecks as a proxy for maritime trading (Parker, 1996; Strauss, 2013); proxies for resource collecting intensity, such as traces of pollution in Greenland ice cores from Roman mining (McConnell et al., 2018); data approximating building activities in the Roman Empire, e.g. data on the construction of public buildings or levels of wood consumption in western Germany (Hollstein, 1980; Jongman, 2014); and the intensity of Roman epigraphic habit as represented by the Latin Inscriptions of the Roman Empire (LIRE) database (Kaš, Heřmáňková, & Sobotková, 2021a,b, for an overview of the potential of scientific approaches to Roman culture, see e.g. Brughmans et al., 2019; Scheidel, 2019). These proxies share similar trends in temporal distribution, i.e. they indicate high values and peaks in the second century CE, particularly in the first half, and a significant decline at the beginning of the third century. In addition, as diverse climatological data suggest (e.g. documented Tiber River flood levels, cosmogenic radionuclides as a proxy for solar activity, glacial retreats, dendrochronology or minerals in cave systems as indicators of changes in temperature), second century CE marks the end of the so-called Roman Climate Optimum (Harper, 2017; Harper & McCormick, 2018). Together, these data demonstrate that during the second century CE, the Roman Empire was more prosperous, politically stable, and affluent than in the third century CE. It was particularly the first half of the second century that can be put into contrast with the time of instability in the third century CE. In addition to the aforementioned data, and as was already noted earlier, in the period between 117 and 165 CE, the Roman Empire reached its largest territorial extent, no Roman emperor was assassinated, and there was a relatively low density of aggressive offensive wars initiated by an emperor. This temporal window of significant stability and prosperity under the members of the Nerva-Antonine dynasty began to close after 165 CE, when the Marcomannic Wars (ca 166–180 CE) created considerable societal pressure (Blois, 2020; Grant, 2005; Harper, 2017; Scarre, 1995).

We are aware of the difference between the affluence and prosperity as experienced by the general Roman population and that of Roman emperors. However, in this study, we focus primarily on the social environment related to Roman emperors, and the selection of indicators of prosperity and affluence captures aspects of the historical reality that was most probably perceived and followed by this elite social group.

3 Analysis and Results

The next step after establishing the trends and changes in the societal pressures, prosperity, and political stability mentioned in the Section 2 was to explore whether and how iconographic motifs on Roman coinage from the second and third centuries CE reflected these developments and how the results of the analysis compared to the predictions of the affluence hypothesis.

Initially, the downloaded OCRE dataset of coin types was categorized based on their (a) denomination (most common denominations from the period of interest were selected – Antoninianus, Denarius, Sestertius, Aureus, As, Dupondius, Solidus, Quinarius, Quinarius_Aureus, see Figure 2 for their temporal density, on denominations, see also Metcalf, 2012), (b) dates of origins, and (c) deities depicted on the reverse side (i.e. identified in the attribute “description_reverse”) based on the list of deities appearing on Roman coins from OCRE (Meadows et al., 2012). In addition, to capture coin types mentioning deities in the legend on the reverse side but without a figurative depiction of the deity (i.e. types depicting an altar), we filtered such coin types in the dataset based on their “ontology#hasLegend_reverse” attribute, and by using this method, another 134 coin types from the OCRE dataset were categorized as promoting a deity. Based on our filtering, 26,534 coin types were identified as mentioning or depicting a deity or deities. With the numismatic data categorized based on those values in a dataframe, it was possible to explore the changes in diversity in types of deities depicted on
coin types and temporal trends in representations of deities with specifically oriented aspects such as war and those related to defense or morality. In this article, we use the category “deity” for gods, goddesses, and divine personifications of certain qualities such as virtues (e.g. Pietas, Justitia, Concordia) since personifications were attached to the Roman religious life, received cult, and were included in the list of deities also in the OCRE project portal (for the divine nature of Roman personifications, see e.g. Hornblower, Spawforth, & Eidinow, 2014, p. 583).

To check whether the proportions in the number of deities depicted on coin types in the OCRE dataset are not skewed by individual denominations, e.g. whether a deity was portrayed on golden coins only and was thus distributed among the general population in a limited fashion because of the high value, we conducted a correlation analysis of deities depicted on coin types based on denominations. The outcome of the Spearman correlation coefficient analysis revealed that the distributions and representations of deities on individual denominations are strongly mutually correlated, and we can thus consider such biases very limited. The exception from the pattern is Solidus, with lower correlations across the spectrum of denominations; however, deities depicted on coin types of this denomination represent only 5% of the data, and on a temporal scale, Solidus was introduced at the beginning of the fourth century CE (Supplementaries S1 (coin types with deities percentages based on denominations) and S2 (Spearman correlation of deities proportions on coin types of different denominations)). It needs to be noted that the analyses presented here were conducted on the level of coin types developed by the imperial administration and do not capture the domain of exemplars of individual coin finds and their potential distribution among population (for analyses based on individual finds of coin types, see Noreña, 2011).

The first analytical step toward testing the temporal trends was to identify the 20 most frequently depicted deities at the time of the Roman Empire, explore their temporal distribution, and identify patterns for further evaluation (Figure 3).

The graph shown in Figure 3 portrays temporal changes in percentage portions of coin types depicting the 20 most commonly appearing deities from all coin types minted. As a common rule for the temporal analyses, we implemented a rolling average of 10 years to the percentage portions to compensate for the individual years where no coin types were issued. The main explanatory power of the graph lies in revealing large-scale temporal shifts in the overall proportion of different deities represented on coin types. Such a shift is apparent in the first half of the second century CE, when the coin types depicting the 20 most frequent deities constitute a significantly lower portion of all coin types depicting deities for several decades than during the years before or after. In the same time frame, the portion of coin types depicting certain deities also changes significantly when compared to the first century CE (e.g. Victory, Pax, Pietas, Mars). These patterns were explored in greater detail in subsequent steps. To examine the situation in the first half of the second century CE in terms of

Figure 2: The temporal distribution of the most common denominations of coins in the Roman Empire.
diversity in the total number of different deities represented on coin types, we applied the inverse Herfindahl–Hirschman index, which is a function for determining diversity in data that takes into account how evenly the data (in this case individual deities on coin types) are distributed (Figure 4).

The diversity analysis (Figure 4) supports the earlier observation that the first half of the second century CE was a time of a major shift in the iconographic trends in Roman coinage. When compared to the second half of the second century CE and the first half of the third century CE, the period between ca 120 and 160 CE is marked by high and lasting diversity in the number of different deities represented on coin types. In other words, a number of deities were newly introduced or re-introduced in this timeframe on coins, weights of promotion of established deities shifted, and moralizing deities outside of the 20 most common deities described earlier contributed to this diversification trend (e.g. Pudicitia, Indulgentia). Another peak in

Figure 3: Temporal distribution of the 20 most frequent deities depicted on coin types. The thickness of individual colored belts represents the percentage portion of coin types depicting a particular deity from all coin types depicting deities minted in a given period of time with a 10-year rolling average. All coin types depicting other deities outside of the 20 most frequent ones are represented by “rest.”

Figure 4: Diversity in the number of unique deities represented on coin types in a given period; the graph is normalized by the inverse Herfindahl–Hirschman index.
diversity can be observed in the second half of the third century CE; however, it is not as temporally consistent or lasting as in the second century CE.

After revealing these developments in the diversity of the iconographic motifs in Roman coinage, we narrowed the focus down to the temporal changes in the percentage portion of coin types with specific deities representing crucial imperial ideological messages relevant to testing the affluence hypothesis. The deities were selected and categorized based on aspects promoting different life strategies and conditions, i.e. deities oriented toward universalistic power and dominance, war and defense, morality, or strong emphasis on cooperation.

Mars, Pax, Securitas, and Virtus, i.e. martial and defense-related deities depicted on Roman coins, constituted one group of interest. While these deities, together with the majority of the Roman pantheon, were to some degree oriented on cooperation, they were particularly closely associated with mitigating dangers from conflicts, i.e. a very specific negative condition. The initial hypothetical expectation of the temporal trends in this martial group was that they were more frequently issued on coin types in times when the Roman Empire was in external or internal conflicts, or shortly after such conditions ended. Although Mars had other aspects attributed to him (e.g. as a god of agriculture), his role as the god of war was significant. Virtus, in Roman practice, was frequently representing the virtue of valor and courage in war or competitive endeavors (Noreña, 2011, pp. 77–82). Deities such as Pax and Securitas were then selected as personifications of peace and security (Denova, 2019, pp. 79–80; Manders, 2012, pp. 199–211; Rüpke, 2011). Although Noreña explored trends of Virtus and Victoria in Roman coinage as “military types” together, Victoria was incorporated in a different group in this research (see the following paragraph, and see replication of Noreña’s results in Section 4). Noreña’s observations of Victoria and Virtus types on a timeline claimed that coins depicting these two personifications were minted in lower numbers throughout the second century CE, with two upward surges during the reign of Trajan (98–117 CE) and Septimius Severus (193–211 CE), with some increase also in the time of Marcus Aurelius (161–180 CE) (Noreña, 2011, pp. 77–78, 240–42). Our temporal analysis of martial and defense-related deities shows similar results (Figure 5). Coin types with Mars, Pax, Securitas, and Virtus were minted in very low frequencies during the first half of the second century CE. Although these four deities were depicted on coins significantly more frequently in the third century CE, the upward trend occurred at different periods for each of the iconographic motifs. Coin types with Mars surged in percentage around 150 CE, similarly as Virtus, then again in the first half of the third century, while types with Pax occurred more often later, with a significant upward shift in the trend around 250 CE. Coin types with Securitas were minted with gradually and slowly rising frequency, peaking in the first half of the third century CE.

Figure 5: Temporal distribution of percentage portions of coin types depicting martial and defense-related deities, i.e. Mars, Pax, Securitas, and Virtus from all coin types minted in a given period of time with a 10-year rolling average.
The deities Victoria, Jupiter, and Sol were deities with universalistic aspects linked to dominance and power. At the same time, we recognize that there are significant overlaps in aspects between this and the martial group (e.g. Noreña classified Victoria as a martial type, 2011, p. 241), and the initial prediction was that dominant and powerful deities occurred in coinage more frequently in times of conflicts or in times of internal political crises as promises of power and strength. It is, however, possible that due to the universalistic aspects of these deities, we might expect that the fluctuation in temporal trends will not be as significant as in the other, more focused groups. The goddess Victoria was a personification of the victory of the Roman Empire and its emperors. Jupiter was the chief deity of the Roman pantheon; Sol also symbolized imperial power and was often accompanied by the attribute Invictus (i.e. the Unconquered Sun) (Denova, 2019, pp. 75–76, 91; Manders, 2012, pp. 77–87; Rüpke, 2011). As was the case for martial and defense-related deities, Victoria, Jupiter, and Sol were, based on the analysis, comparably depicted significantly less frequently on Roman coinage in the first half of the second century CE than in the second half of the second century and throughout the third century CE (Figure 6).

Next, we focused on the temporal trends in percentage portions of coin types depicting moralizing deities, which are highly relevant for the study of the emergence and development of moralizing motifs in ancient religions. Specifically, the affluence hypothesis predicts that moralizing religions should be more frequently emerging in affluent times and not as much in times of crisis. We selected 10 core moralizing personifications from the most represented deities on coin types. The personifications in this group are Pietas (proper devotion to the gods and family), Aequitas (just administration, also in relationship to the imperial mint), Justitia (justice), Salus (good health and well-being), Clementia and Indulgentia (mercy, leniency, or forgiveness), Concordia (agreement or concord in society), Pudicitia (sexual modesty), Liberalitas (generosity), and Aeternitas (eternity, or permanence in prosperity) (see discussion on their aspects in Fears, 1981; Manders, 2012; Noreña, 2001, 2007). The first remarkable trend is a significant increase in the frequency of personifications of all these moralizing values on coin types in the first half of the second century CE (Figure 7, with Aequitas being an outlier from the common trend). The second observation in this step is the noticeable decrease in the frequency of these coin types towards the third century CE. After the decline towards the third century, some of the moralizing deities (i.e. Salus, Concordia, Liberalitas, Pudicitia, Aequitas) were depicted frequently again in the third century but have no observable mutual pattern. Manders offers one explanation for the specific temporal trend of Aequitas on coins, and she claims that it was essential and commonplace for almost all emperors to promote Aequitas on coins in the sense of just administration since every ruler had to possess it to apply ius gentium (i.e. a form of natural law; Manders, 2012, pp. 182–185).
To explore and compare the temporal trends between the individual groups of coin types based on the deities they depict, we simplified the temporal distributions of individual deities in each group to one trendline per group and visualized it on a graph (Figure 8). In addition, to compare these temporal dynamics against an indicator of prosperity, we visualized the temporal distribution of Roman Latin epigraphic habit as represented by the LIRE dataset (Figure 8) in the form of cumulative kernel density estimation plot of 100 simulated
time series (for script, see Glomb & Kaše, 2023; for LIRE, see Kaše et al., 2021b; for approximating prosperity in this manner, see Kaše & Glomb, 2022).

On the basis of the temporal trends of the percentages of individual deities depicted on OCRE coin types categorized in three groups based on their aspects as visualized in Figure 8, we can make the following observations. The biggest difference can be observed in the temporal distribution of moralizing deities when compared to the two other groups (martial, dominant). While the trendline for moralizing deities is bell shaped with the upper peak in percentage in the first half of the second century CE and decline in the second half toward the third century CE, trends of martial and dominant deities are U-shaped with the most significant dip in percentages in the first half of the second century CE and increase toward the third century CE. If we compare these trends in coinage with the epigraphic trend as represented by the LIRe database, we can observe a wider bell-shaped trend, peaking in the first half of the second century CE and a decline in the habit in the third century CE. While the epigraphic habit is indicative of affluence rather on the level of the general population, and iconographic motifs on coins were selected by Roman elites, it needs to be repeated that Roman imperial propaganda was part of a dialogue between the ruling hierarchy and sentiments of the population. Therefore, the observation that (a) moralizing deities were most frequently promoted on coin types in the time of peaking epigraphic habit, and (b) martial and dominant deities were at that time comparably significantly less promoted, is very relevant and more in support of the affluence hypothesis. This being said, moralizing deities on coin types were not promoted in a continuous decline throughout the whole third century CE, and there was an increase around the half of the third century CE, mainly constituted by Aequitas and Liberalitas percentages, until the declining trend returned.

Finally, to statistically check the mutual dynamics between the deities on coin types without restricting them to the groups, we conducted a correlation analysis of the temporal trends for individual deities. Since the data are a time series, it was more mathematically appropriate to calculate and compare the relative percentage changes in time for each deity rather than directly analyzing correlation using the percentage portions themselves. In other words, correlation analysis of percentage change rather than correlation of levels themselves is one way of how to mitigate the impact of potential coincidental mutual trending and provide nuanced correlation results (see Kirchgässner & Wolters, 2007, p. 153; Stoffer & Katzoff, 2006, p. 322). We compared the percentage changes from the temporal trends of individual deities on coin types pairwise for similarities using Spearman’s correlation coefficient (Figure 9). Spearman’s correlation coefficient ($Rs$; min $-1.0$ = perfect negative correlation, and max $1.0$ = perfect positive correlation) measures the strength and direction of the

![Figure 9: Spearman correlation matrix for the deities from the three groups (martial- and defense-related, powerful and dominant, and moralizing) represented on coin types for the period of 100–250 CE. Statistically significant values (i.e. with the $p$ value lower than 0.05) are in bold.](image-url)
association between two ranked variables and is suitable for evaluating correlations in which the variables do not possess a normal (Gaussian) distribution, which is the case for the time series data analyzed in this article. The time frame for this analysis was the period between 100 and 250 CE, as most of the deities from the three groups are represented on the timeline for the entire duration with the exception of Sol, Aeternitas, Indulgentia, and Clementia; in the event of a wider temporal frame, more deities would be excluded. In addition, the period between 100 and 250 CE is the key time frame for changes in prosperity and societal pressures in the Roman Empire as described in earlier sections.

The correlation analysis yielded statistically significant results (documentation and scripts in Glomb & Kaše, 2023). Overall, the deities with martial and dominating aspects tend to correlate positively with each other with respect to percentage changes in the portions of coin types on the timeline. In contrast, these groups tend to correlate negatively or not correlate at all with the moralizing deities, and the moralizing deities rather tend to correlate positively with each other. Upon inspecting the correlation matrix, there are some exceptions, such as again Aequitas with correlations outside this pattern, or Jupiter with a weak positive correlation with Salus, or a correlation between Securitas and Liberalitas; however, the overall pattern is clear even outside the statistically significant correlations: the temporal trends in the coin types depicting moralizing deities generally follow different dynamics when compared to martial and defense-related ones and to powerful and dominant deities in the period of 100–250 CE.

4 Conclusions

Our analysis of the iconographic motifs on the reverse sides of coin types represented by the OCRE dataset yielded three key results relevant for further interpretation in the context of the affluence hypothesis: (1) the first half of the second century CE was a time of a significant increase in the innovation and diversity with respect to the numbers of individual deities represented on Roman coin types with a relatively consistent decrease in this quality in the third century until a short-term peak in the data from the second half of the third century CE. Part of this diversification was the major introduction or re-introduction of virtues on coin types such as Liberalitas, Providentia, Pudicitia, or Indulgentia; (2) martial- and defense-related deities such as Mars, Securitas, Pax, and Virtus were minted on coin types significantly less frequently in the first half of the second century CE than in the preceding or subsequent periods. A similar pattern was observed for deities with aspects of dominance and universal power such as Victory, Jupiter, and Sol; this observation is also in alignment with Noreña’s results for trends of Virtus and Victoria on types from his sample (2011, p. 241); (3), and overall, the analyzed deities relating to moralizing values were depicted on coin types with an increased frequency in the first half of the second century CE. From this group, Pietas, Aeternitas, Justitia, Clementia, Indulgentia, Pudicitia, Salus, and Concordia were more often represented on coin types in the first half of the second century CE than in the second half of the second century, when their representation on coins began to decline. In the third century CE, these deities mostly remained in decline, with the exception of Pudicitia, Salus, and Concordia, which returned to the body of Roman coinage in fluctuating temporal trends. Liberalitas and Aequitas stand outside of the downward trends related to this group after the second century CE and were represented on coin types more often until the first half of the third century CE.

The results suggest that when compared to the first century CE, the first half of the second century CE stands out on the timeline as a period of a major topical shift in the iconographic representations and legends on the reverse sides. This topical shift, however, did not endure in the same form in the subsequent periods and, since the second half of the second century CE, some of the more moralizing topics that were promoted earlier on coins declined with respect to the frequency in representation on coin types, while martial- and defense-related representations together with those oriented towards dominance and power behaved to some extent in an inverse manner, i.e. they appeared significantly more often on coins after the first half of the second century CE. These dynamics in the temporal relationships between the groups of analyzed deities on coin types are supported by several statistically significant correlations of the percentage changes in the portions of coin types for the period of 100–250 CE.
In the context of societal pressures, degree of prosperity, and affluence, the first half of the second century CE also stood out. As described earlier in this study, the selected proxy data suggest that the second century CE was, overall, more stable in terms of the Empire’s politics, environment, and prosperity than the third century. In addition to a very low frequency of assassinations in the second century and the relative longevity of the reign of individual emperors, there were several decades without aggressive offensive conflicts. Between Trajan’s invasion of Parthia (117 CE) and the onset of the Marcomannic Wars and Antonine Plague (ca 165 CE), no assassinations of Roman emperors took place, and the only major conflict in that period was the response to the Bar Kokhba revolt in the eastern Roman Empire (132–136 CE) (Harper, 2017, pp. 23–118; Scarre, 1995, pp. 90–125).

In regard to the test of the validity of the affluence hypothesis (Baumard et al., 2015; Baumard & Chevallier, 2015), the results of the correlation and diversity analysis of Roman imperial ideological trends as represented on coin types from the OCRE dataset, together with the temporal modeling of Roman Latin epigraphic habit as represented by the LIRE database, support the hypothesis’ predictions. However, it should be emphasized that the research presented here constitutes a very specific and small-scale test capturing the possible behavioral changes and preferences in values at the top of the Roman social hierarchy. Nonetheless, the statistically supported observation that (a) innovation in the iconography of coin types and (b) the increase in depictions of moralizing deities (with a decrease in martial- and power-oriented ones) are trends occurring simultaneously in times of relative stability and prosperity, and in time of the peak in epigraphic habit, is highly relevant for the understanding of both (a) Roman imperial ideological propaganda and (b) conditions beneficial for the emergence of moralizing aspects in cultural space.

Finally, the added value of this article in the debate on quantitative approaches to ancient coinage is the replication of Noreña’s results (e.g. for trends of Virtus and Victoria, see Noreña, 2011, p. 241) by different methods of coin type analysis that were utilized in a similar manner by Manders (2012).

5 Discussion

The research presented here further confirms the potential of numismatics as a culturally rich source that is suitable for large-scale temporal quantitative analyses in historiography and is comparable to archaeological (see e.g. Romanowska, Bobou, & Raja, 2021), literary (see e.g. Czachesz, 2016; Kaše, Nikki, & Glomb, 2022), or epigraphic evidence (see e.g. Glomb, Kaše, & Heřmánková, 2022). This article focuses on the iconography of supernatural entities on the reverse sides of Roman coins and thus is not exhaustive in regard to other valuable information stored on Roman coinage. One of the potential future avenues of research in the topic explored here might be further classification and evaluation of textual legends accompanying the iconographic motifs to nuance these trends in greater detail.

As was described earlier in the article, this research does not capture the perception of affluence, stability, and prosperity in the Roman Empire on the level of the general population; it is oriented toward the perception of these qualities and reflections of popular sentiments on the social level of Roman elites due to the explored medium. However, a potential test of the affluence hypothesis that would transfer the focus to the Graeco-Roman population can be conducted in the near future. There are now representative digital databases of Latin and Greek epigraphy in machine-readable form accompanied by attributes such as geocoordinates or dates of origin, making it possible to explore the occurrences of moralizing motifs in the epigraphic habit (Kaše & Heřmánková, 2021; Kaše et al., 2021b).

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