Central Bank Digital Currencies

A Pilot Study for Hong Kong

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Abstract

Digital currencies are the digital form of fiat money and have been recently warranting global attention. In fact, more than 80% of central banks are exploring the feasibility of Central Bank Digital Currencies (CBDC) programs, and 10% will soon issue CBDCs. Existing research relating to digital currencies is primarily focused on B2B applications and impacts on financial markets. However, there is a lack of research focused on user acceptability and privacy issues of digital currencies, aspects that are very relevant to the B2C and retail markets. This research project analyzes user acceptability and privacy issues of digital currency in the retail sector and provides recommendations for possible implementations of these technologies in Hong Kong. This is achieved by conducting a literature review to understand previous CBDC experiments, then executing focus group discussions and surveys, followed by data synthesis and analysis. Key findings of the report include the fact that data privacy is not a dominating concern for potential CBDC customers in Hong Kong and a network effect is crucial for early adopters of CBDC. Additionally, there is a prevailing sentiment amongst local students who are averse to the local or central government spearheading this project; this is mainly due to political sentiments. Based on the findings of this report, it is recommended that Hong Kong's CBDC is deployed when the political climate must be suited for the CBDC rollout and political rumors revolving around the CBDC need to be minimized. This can be done through positive marketing of the benefits to consumers, allowing them to see the authentic intentions of the CBDC development. Furthermore, it is recommended that the CBDC integrates with Octopus and ePayment by providing services to transfer to and from Octopus and ePayment wallets, as this is a service that is not currently available and hence this can be a major selling point for the CBDC.

Introduction

Central Bank Digital Currencies (CBDCs) are a modern means of payment whereby money is exchanged digitally. As the name suggests, CBDCs are centralized. And it is issued and regulated by the relevant monetary authority. There have been several CBDC pilot programs globally; some were successful and developed to nationwide deployment (e.g., Project Sand Dollar in Bahamas), whilst other programs failed to gain significant public support (e.g., E-Krona in Sweden). The success of CBDC programs is highly contingent on how well the design & implementation of CBDCs suits the values, preferences, and expectations of consumers.

Therefore, the objective of this research project is to conduct an in-depth investigation into the user acceptability and privacy issues of digital currency in the retail sector and provide recommendations for possible implementations of these technologies in Hong Kong. This will be achieved through: firstly, a literature review on successful and unsuccessful implementations of CBDC in other regions of the world, with an analysis of their successes and failures and what Hong Kong can take away. Secondly, focus groups will be conducted to conduct an in-depth exploration of this consumer sentiment, with the intention to discover key considerations for the design and implementation of a CBDC. Thirdly, over a hundred participants will be surveyed to gain statistical evidence on consumer perceptions of a CBDC if it is deployed in Hong Kong. Finally, these findings will be synthesized and recommendations will be provided for a Hong Kong CBDC.

Literature Review

Introduction

Fiscal and monetary authorities' attention is drawn by the increasing circulation of consumers' cash and credit shifting towards non-bank payment services providers and Fintech companies. The electronic wallet (e-wallet) has already prevailed in regions like Kenya (M-Pesa) and China (Alipay & WeChat Pay), where the value of total transactions through Alipay and WeChat Pay exceeds the combined worldwide volume of Visa and MasterCard (Adrian & Mancini Griffoli 2019).

As technology companies are disintermediating financial institutions at the currency level; cash and bank deposits are gradually replaced by balance in e-wallets, since e-wallets offer consumers a more personalized payment method. Foreseeably, this shifting trend will cause profound implications for existing payment channels, monetary systems, and even affect global financial systems.

Facing the question of following the trend of e-wallet while keeping control of the financial system, the emergence of Central Bank Digital Currency (CBDC) becomes a solution.

Pioneering by e-Krona (Sweden), e-Peso (Uruguay), and e-Hryvnia (Ukraine), these first-ever retail CBDCs established several attempts towards the design, structure, and technology innovations from the national level, which might not be perfect but still meaningful for future exploration.

Following by the pilot studies in Caribbean and Bahamas' sand dollar, CBDCs show strong ability in the emerging retail market by technological innovation adapting to their social and geographical conditions.

Moreover, in mid 2020, the pilot testing of digital currency electronic payment (DCEP) in Mainland China, known as digital Yuan, draws the attention from all over the world. The surge of applying CBDCs in the retail sector inspires the project to investigate more on the potentiality of digital currencies in the Hong Kong retail market.

Based on overall investigation of social media's news articles, the public seem to put their concerns on privacy protection and user acceptability, to be more specific, the anonymity problem, convenience improvement, offline usage, etc. The project will especially focus on the above public concerns, and corresponding literature review is conducted below.

First-ever Retail CBDCs

In light of the decline of cash usage, countries like Sweden, Uruguay, and Ukraine have started their exploration in central banks digital currencies (CBDCs) since late 2016 (Skingsley, 2016).

The e-Krona from Sweden was initiated in early 2017, while still undergoing its phase 3, technological implementation design in 2020 (Riksbank, 2020). One of the key factors for its slow process is that card payments are totally dominant in Sweden, with near 60% in 2018. Even though the prevalence of card payment provides the cashless environment in Sweden, it also hinders CBDC's development due to people's lack of incentive in switching to another cashless payment method. Moreover, Sveriges Riksbank (2018), the central bank of Sweden, points out the inherently strong network effects in the payment market, leading to heavy market concentration in a global landscape. The network effect results in "the chicken and egg problem" that consumers and merchants will only use the payments if it is widely accepted. Inspired by above, the trend of following crowds becomes an investigating perspective of this project.

The e-Peso project in Uruguay shows more interest in privacy protection (Álvez, Lluberas and Ponce 2019). Technological implementations include anonymity of P2P transactions, unique cryptographic signature with a specific denomination, etc. Because of its special consideration in anonymity features and interest-bearing properties (consumers' incentive), e-Peso project is regarded as a successful pilot by the International Monetary Fund (IMF) and Bank for International Settlements (BIS).

The last one in first-ever retail CBDC pilot projects is e-Hryvnia from Ukraine. It made its meaningful progress by providing the most technical details among three pilot projects, and the national bank in Ukraine successfully tested an electronic form of its currency, e-Hryvnia, in a 4-month pilot operation period in 2018 (National Bank of Ukraine, 2019). Moreover, compared to other two pilot projects, e-Hryvnia stands out by its efficient implementation process, in which three phases are done throughout 2018.

The exploration of three first-ever retail CBDCs are considered to be meaningful in technology and model design. They provide referenceable implementation for some general concerns, such as anonymity features, interest-bearing properties, financial inclusion, etc. However, they are short at adapting the special situation of their market, in comparison to the following CBDC projects. Hence, these pilot projects of first-ever retail CBDCs stick in the theoretical and testing stage for a long time, rather than proceed to issuance quickly.

Nationally Deployed CBDCs in Caribbean

The Caribbean is home to some of the first central bank digital currencies deployed on a national scale. The Bahamas and the Eastern Caribbean Islands (comprising The U.S. Virgin Islands, The British Virgin Islands, St. Maarten, and Puerto Rico) have launched their own CBDC, with The Bahamas recently deploying their CBDC on the national level. As these regions are some of the first to take this technology to the market, there are plenty of aspects for Hong Kong to learn from.

One of the main reasons Caribbean authorities could quickly take their CBDC to market is because there was a strong need from the consumer standpoint. The Caribbean is frequently hit by natural disasters such as tsunamis and hurricanes, and as most homes reside close to the sea level, they are often adversely affected. The economy after a natural disaster is damaged and slow to pick up: transactions do not happen as frequently because shops are damaged, and it is also difficult to access ATMs and banks. Furthermore, the problem of under-banking is exacerbated during these times. Hence, there is clearly a serious problem that a CBDC can solve as it provides a digital form of money and one that can withstand disasters which The Caribbean frequently experiences. Resultantly, after The Bahamas CBDC project pilot in a small island region called Exuma, they only took a few months to launch the project to the whole country (Bharathan 2020). Hong Kong can learn from these regions by identifying serious pain points which consumers face and developing solutions to fix those.

Interoperability is a key aspect which The Bahamas' Project Sand Dollar solves, and one that Hong Kong could also focus on. The Bahamian authorities observed that with the increasing number of payment service providers and mobile wallets, consumers are having a difficult time juggling multiple platforms. Furthermore, most of these platforms do not have a means of communicating with each other. To solve this problem, authorities created API frameworks which let payment service providers communicate with their counterparts, promoting innovation and competition (Ossinger 2021). This could be something Hong Kong learns from, as it would be a boon to customers if companies like WeChat, PayMe and AliPay can work in harmony with each other using a CBDC as a basis.

Moreover, these regions have incorporated offline functionality into their implementations of CBDC. Both the Bahamas and The Eastern Caribbean have enabled peer-to-peer transactions for small amounts. This shows that the technology has matured and it is possible for regions such as Hong Kong to implement similar technology. However, it is uncertain whether there will be a *need* for this technology in Hong Kong because of the advanced and reliable internet infrastructure in the city.

Focus Group Discussions

Introduction

The objective of the focus group discussions is to conduct an in-depth exploration of this consumer sentiment, with the intention to discover key considerations for the design and implementation of a CBDC in Hong Kong.

Seven focus group discussions were conducted with a total of 9 students; each discussion had 1 or 2 participants. All the participants were students from universities in Hong Kong. The reason why all participants are university students is that it is most valuable to understand the sentiment of the Hong Kong youth (as opposed to working-age people). Because once CBDC is rolled out in the city, the youth will be the main users of CBDCs. The academic and cultural background of the participants was as follows:

Academic Background (Total = 9)					
Arts	Business & Economics	Engineering	Medicine	Science	Social Science
2	2	1	2	1	1
Cultural Background (Total = 9)					
Local		Mainland		International	
4		3		2	

Each focus group discussion began with a 5-minute information session, where participants were briefed on CBDCs through the pilot programs in China and The Bahamas (see Appendix I). Then, a 40-minute open-ended discussion (see Appendix II) followed with moderators probing deeper into the participants' thoughts and feelings on the mentioned CBDCs, in addition to a potential CBDC deployment in Hong Kong.

Key findings

Critical Factors of Using CBDCs

Critical factors of payment preference (descending order):

User inclusion ≈ Network Effect > convenience > privacy concerns

One of the most important *pull factors* for students to use CBDC is user inclusivity (emphasized by 67% of participants). Currently, mainland students fail to use Alipay (HK) due to the requirement to bind bank cards and issues in the identity verification process (they cannot use non-permanent HKID for verification). A similar problem arises for local students signing up for WeChat Pay. When the idea of CBDC was introduced to focus group participants, over half of them showed interest in the CBDC because of the potentially higher levels of financial inclusion.

Apart from financial inclusion, participants also emphasized the "Network Effect" (aka. Herd effect) in determining their payment preference. The network effect denotes that if surrounding people use a particular payment method, a person is also likely to become a frequent user of that payment method, even though the person is dissatisfied with some of the technology.

As for privacy, it was interesting to note that most participants showed significant concerns about privacy at the beginning of the discussion. However, as the discussion progressed, more than three-quarters of them admitted that privacy is not a significant issue in their daily usage unless there are severe problems (e.g., large data breach). It is accessibility, peer's preference in payment, and convenience that genuinely affects participants' payment choice.

The key factors of using CBDCs are indicated below:

Key Factors	**Percentage of recognition**	**Supplementary Comments**
User Inclusion	88.89%	1. Since interviewees are from various backgrounds; some cannot access WeChat pay due to the long process of ID card identification & failure to register by overseas phone numbers.

		2. Some e-wallets can only store CNY and are linked to CNY accounts. Local and international participants cannot deposit or withdraw money from those e-wallets.
Network Effect	66.67%	1. The initiation of many participants to adopt a new payment method is because of bill recipients' payment preferences. For instance, doing bills split with mainland students usually leads to the usage of WeChat pay. While hanging out with international students may involve PayMe transfers. 2. The more frequent interactions with a certain group of people, the more likely they have the same payment preference.
Convenience	55.56%	The integration of payment devices affects users' choices a lot. For instance, student Octopus can neither link to Octopus App on mobile phones nor do NFC spending. Thus, students will switch to adult octopus, even if they cannot enjoy students' discounts.
Privacy Concerns	66.67%	Many participants recognize this problem and show concern towards it. However, they admitted that many privacy-related privileges could be sacrificed for better convenience or other reasons
Other factors	\	1. Some people care about the "monetary advantage" of payment methods, such as earning interest by deposit, enjoying discounts in some shops, etc. (identified by 22.22% of participant) 2. Hygiene concerns in the pandemic. E-payment methods can significantly reduce the frequency of physical contact. It lowers the risk of being infected and makes users feel safer in their daily lives. (mentioned by 22.22% interviewee)

[Table C.1: The key factors of using CBDCs]

Participants' Sentiment

One clear sentiment that students had was the preference for a hybrid model, in which CBDC and cash would both be in circulation. Students believe the hybrid model is very beneficial mainly because

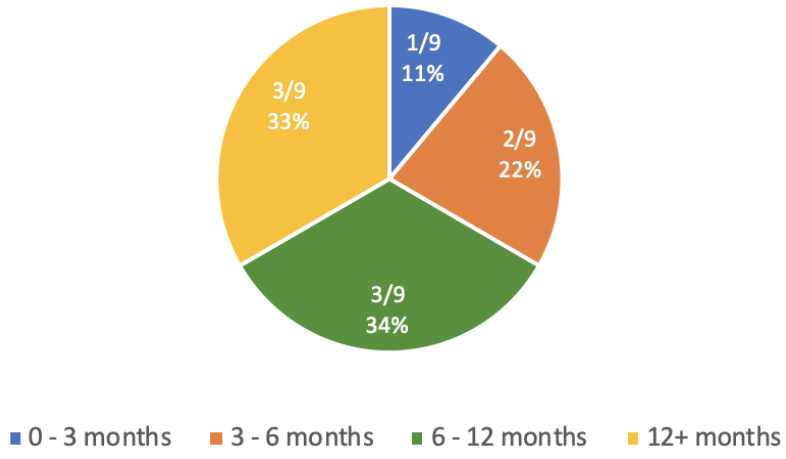
A) cash can act as a backup to CBDC in case of any technical issues, and

B) anonymity can be preserved when necessary by using cash

Another key sentiment is the simple idea of a CBDC sounding 'uncomfortable'. This sentiment was most apparent in students from academic backgrounds such as Social Science and Medicine. The discomforting perception towards CBDC likely stems from the students' lack of use of technology (relative to Computer Science and Engineering students). Their concerns are mainly related to security issues and possibility of incurring additional costs. They show a strong preference to wait for the feedback from other users. People such as these compose a significant proportion of the population, and most of them will probably enter the user pool in the middle or mature stage of the product.

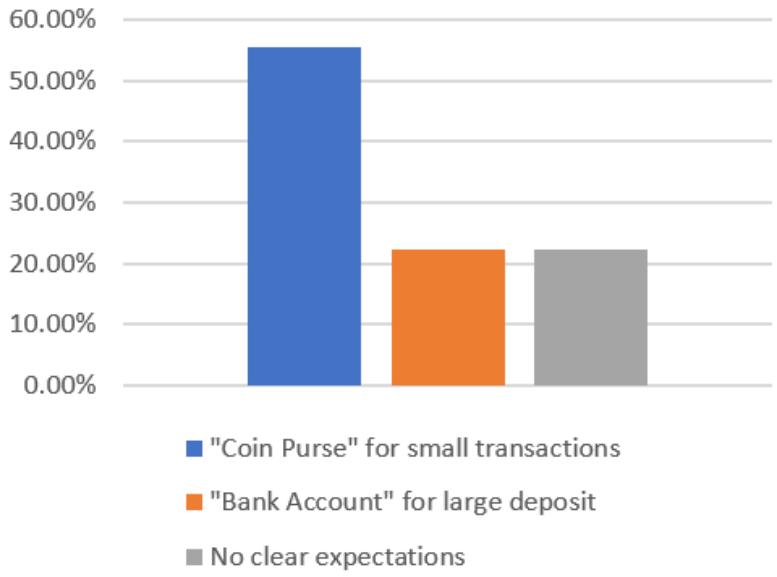
These students do not have a clear idea on whether they will use CBDC, or whether they have strong reasons against it. When a CBDC is introduced, these students are likely to have a crowd mentality. Hence it is imperative that the CBDC founding team emphasize on marketing of benefits to consumers, in addition to avoiding scandals or rumors which can harm public sentiment. This is because the uncertain and indecisive sentiment of students from non-technical backgrounds is representative of a significant portion of HK residents.

In the discussion, if a payment platform is published successfully and promotion goes well, the approximate time participants needed to attempt a new payment method is shown below.



[Fig C.1: Approximate time to try a new payment method after its publication]

Expected Role of CBDC



[Fig C.2: Role of CBDC in users' daily life]

Different students have different expectations and concerns for how CBDC will be used in their financial life. These concerns include governance of currency exchange, savings interest, identity verification requirement, and offline usage.

Some participants expect to use a CBDC wallet as an account for large deposits, since it is supported by the central bank and more secure than other e-wallets. From this point of view, participants will subconsciously compare the functionality of CBDC with bank accounts. Thus, concerns like currency exchange, savings interest, and privacy protection will receive more attention.

Conversely, others may view CBDC as a "coin purse" for small transactions, comparing it with e-wallets like PayMe. This group of participants has minor concerns around privacy or security, due to the small balance in the CBDC wallet. They would care more about the speed, convenience, offline functionality, and accessibility (or financial inclusion) of CBDC under the daily scenarios.

Politics & Privacy

Generally speaking, privacy of CBDC is not a primary concern for students in the focus groups, especially when privacy is compared to convenience and accessibility. However, privacy will become a

major factor if the CBDC rollout becomes politically charged: e.g. there are misconceptions about the motivations for the CBDC rollout shared on social media, swaying the public sentiment.

Though government leadership in CBDC may be unwanted for some students, other students said they preferred the government's leadership because they place more trust in the government than they do in corporations – especially in the status quo where Tencent and Alibaba dominate payment services. One solution that can find the middle ground between the two opinions is to create an independent bank union, supervised by the HKMA, to spearhead the development of CBDC. This may prevent a negative public sentiment as a bank union would imply independence from the government to some extent, and the supervision of HKMA will also guarantee some official trust.

Social Desirability in Discussions

There was a general theme of social desirability in the discussions that took place. For example, when posed with a theoretical question such as 'Do you value convenience more than privacy?', students almost always gave a more socially desirable answer first by confidently claiming that they value privacy more than convenience. However, during the open discussion, students would revise their answer and explain that their initial value for privacy was exaggerated, and that they also value convenience significantly. This discovery indicates that there is likely to be an inherent flaw when gauging consumer sentiment on CBDC using surveys or other market research methods.

Survey

Introduction

The objective of the data analysis report is to conduct an in-depth data analysis based on a survey, with the intention to discover key considerations for the design and implementation of a retail CBDC in Hong Kong and prove or disprove the arguments by statistical testing.

The survey was conducted with a total of 110 students. All the participants were students from Hong Kong universities. The reason why all participants are university students is that it is most valuable to understand the sentiment of the Hong Kong youth (as opposed to working-age people). Because once CBDC is rolled out in the city, the youth will be the main users of CBDCs. The academic and cultural background of the participants was as follows:

Academic Background (Total = 110)							
Arts	FBE	Engineering	Medicine & Dentistry	Science	Law	Architecture	Social Science & Education
6	21	35	19	12	5	4	8
Cultural Background (Total = 110)							
Local		Mainland		International		Prefer not to say	
43		33		28		6	

Each survey is randomly distributed to participants across backgrounds and faculties, with the acknowledgement of ethical approval and consent form. No personal data is collected during the survey and all data will be destroyed three years after the accomplishment of this project (2021.06-2024.06).

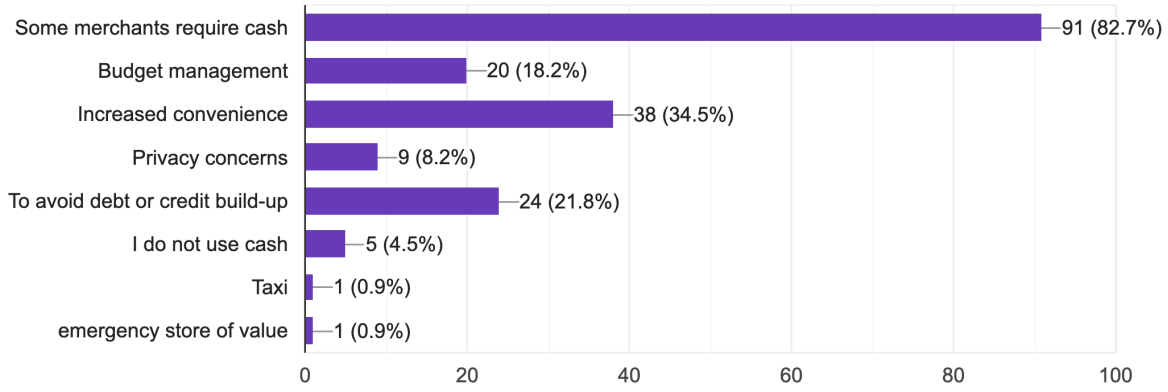
After response collection, several data analysis techniques will be adopted, including visualization, hypothesis testing and regression, in light of supporting the intuitive argument in key findings.

The complete survey in addition to the raw data responses are attached in the appendix.

Key Findings

1. Reason for Usage of Cash

The most significant finding of the survey is the reason for which survey participants use cash, illustrated in *figure D.1.1 below.*

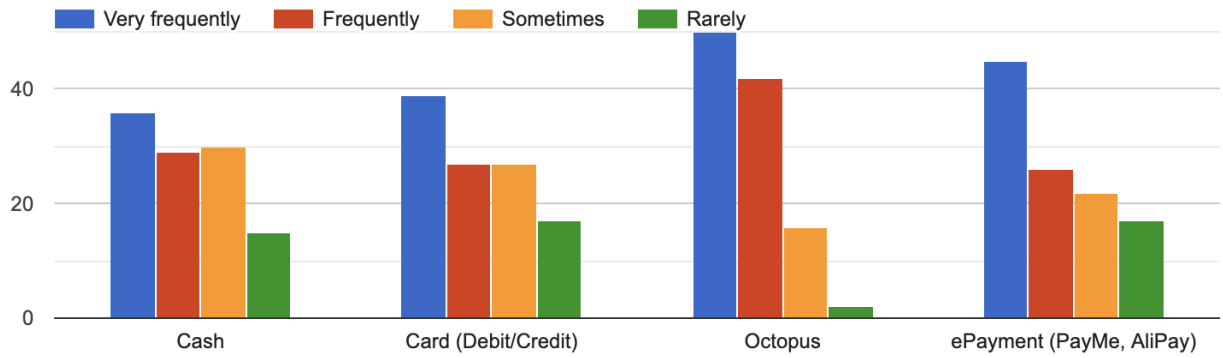


[Fig D.1.1 : Why do you use cash?]

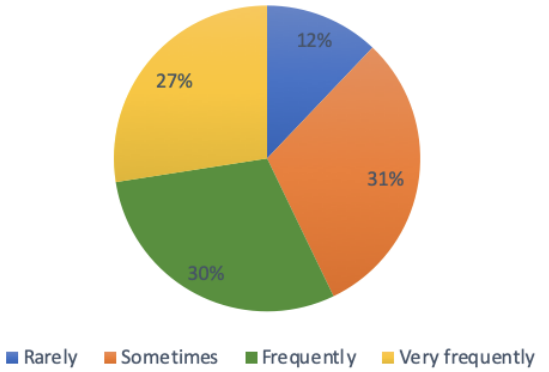
From the results above, it can be concluded that the primary reason surveyed students use cash is because merchants require cash (as cited by 82% of participants). These merchants include pharmacies, Cha Chaan Tengs (茶餐廳) and taxis. If Hong Kong is to transition to a completely cashless society, then the change needs to come from suppliers, who need to abandon their traditional forms of payment collection and adopt more modern methods. This may be difficult to do as several merchants prefer to deal in cash in order to report a reduced income and minimize their tax expense.

2. Frequent Cash Users' Reason for Using Cash

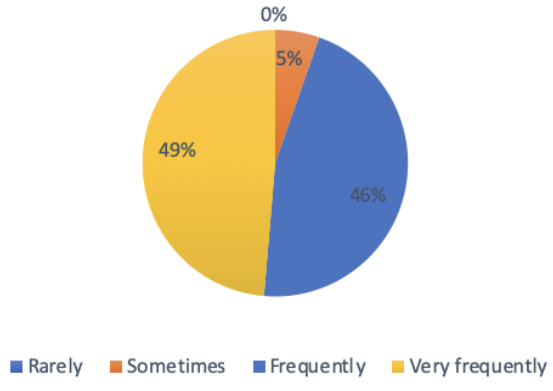
After some simple data exploration techniques, it was discovered that the users which frequently use cash do so for a variety of reasons. Consider figures D.2.2, D.2.2 and D.2.3. These graphs segment the data in Fig D.1.1 based on Fig D.2.1.



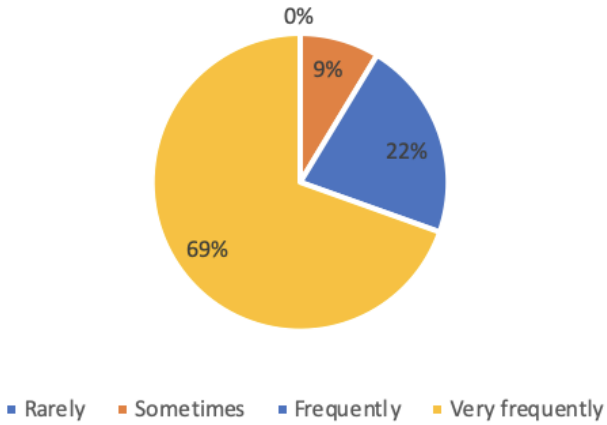
[Fig D.2.1: Please rank the payment methods you most frequently use for your average daily spending?]



[Fig D.2.2: How often is cash used by participants who use cash because 'Some merchants require cash'?]



[Fig D.2.3: How often is cash used by participants who use cash because of 'Increased convenience'?

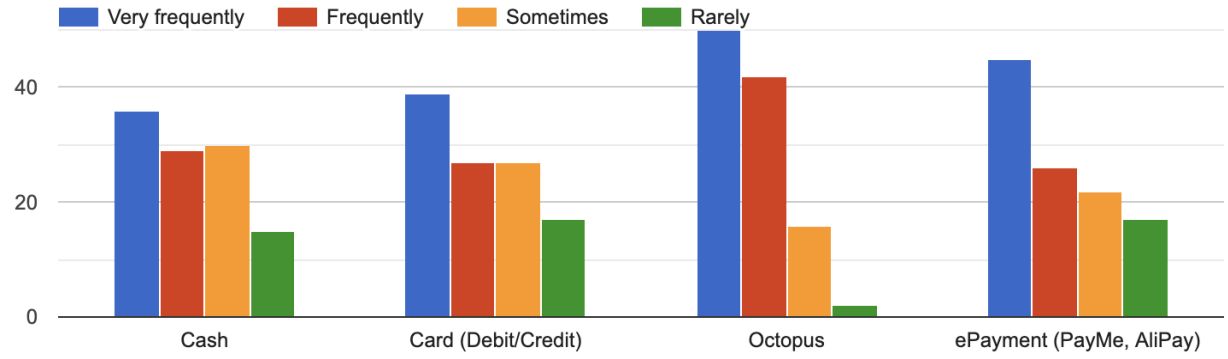


[Fig D.2.4: How often is cash used by participants who use cash 'To avoid debt or credit build-up'?]

Figure D.2.2, D.2.3, and D.2.4 indicate that the participants that use cash most frequently predominantly do so because of *increased convenience* and *to avoid debt or credit build-up*. This means that if authorities truly want the most frequent users of cash to use electronic methods more often then they will need to make it more convenient and cater to debt and credit fears.

3. Market Share of Octopus & ePayment

The survey results show that Octopus and ePayment are already established in the payment habits of survey respondents, as illustrated in Figure D.3.1 below.

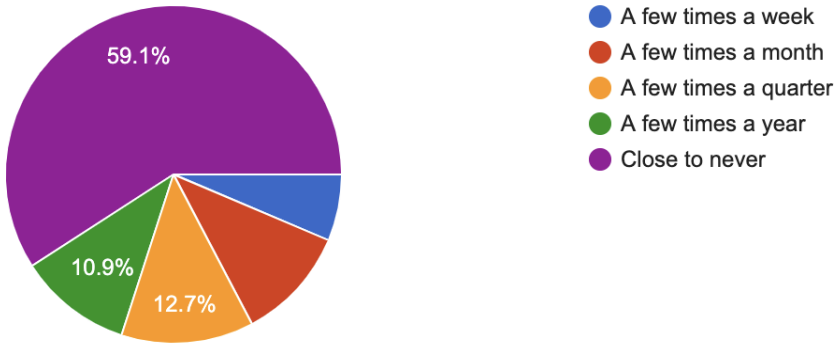


[Fig D.3.1: Please rank the payment methods you most frequently use for your average daily spending?]

The figure above shows that majority respondents use Octopus and ePayment more frequently than cash and credit/debit cards, suggesting that Octopus and ePayment are already ingrained in the payment styles of individuals. This is important information because if a CBDC is deployed in Hong Kong, it will inadvertently be in competition with Octopus and existing ePayment methods.

4. Value of Offline Payments

The survey showed that situations where online payments do not work occurs seldomly, as illustrated in the figure below.



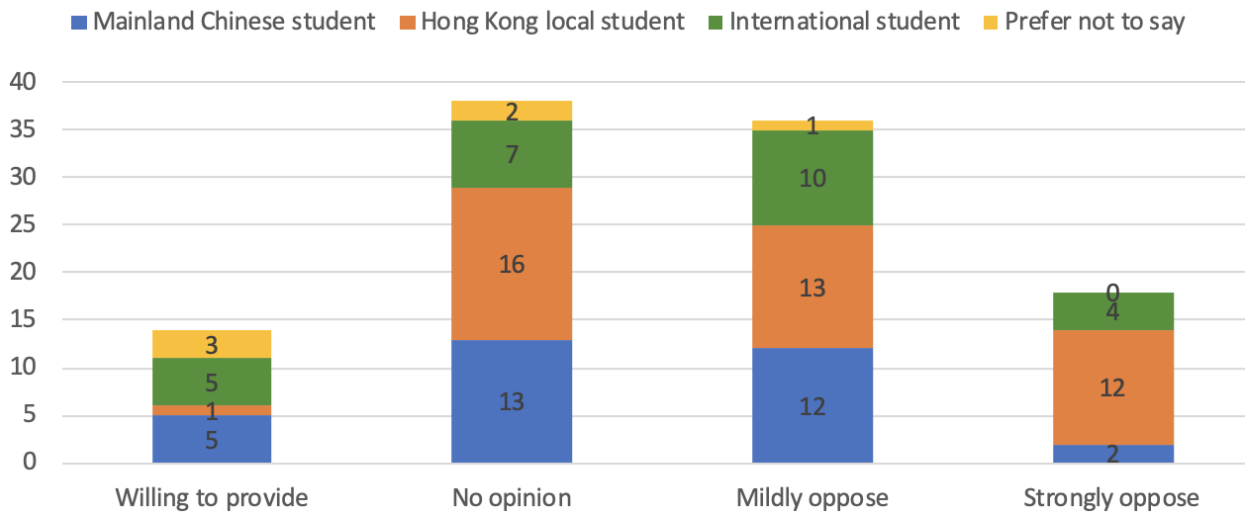
[Fig D.4.1: How often does this situation occur during a payment? Both you and the merchant would like to use ePayment but are unable to due to bad internet connection.]

59.1% of participants claimed that they have almost never faced problems with ePayment due to lack of an internet connection, and above 80% of participants only face such problems a few times a quarter or less. This means that a CBDC's ability to make offline transactions will not be a major attraction for customers; this is mainly due to the excellent internet infrastructure in Hong Kong.

However, several ePayment wallets enable users to make offline transactions when the merchant is online. Furthermore, the Sand Dollar in the Bahamas (which is the first nationally deployed CBDC) enables official transactions when both parties are offline. This implies that the technology for offline payment functionality has matured, and hence including it in HK's CBDC will only be a plus.

5. Data Privacy and Government

The following piece of analysis was conducted by combining data from a question on the cultural background of participants and one on their willingness to provide data to governments.



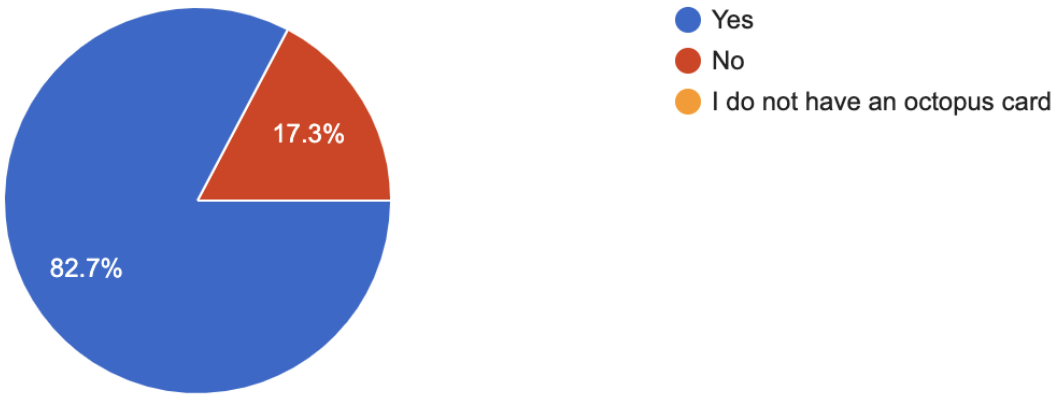
[Figure D.5.1: Cultural Background of Participants and their Willingness to Provide Payment Data to Governments]

The figure above decomposes the count in each category (x-axis) by their cultural background. It is clear that the background of students in the *No opinion* and *Mildly oppose* categories is representative of the general survey demographic. However, it is interesting to note that *Strongly opposed* category is heavily dominated by Hong Kong local students. This suggests that there is a certain demographic of the youth that may be averse to a government-led CBDC.

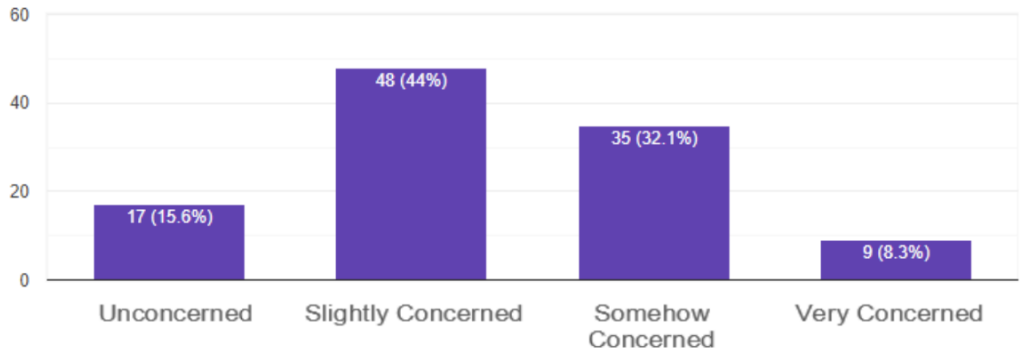
The solution for this is to market the CBDC as an independent project from the government and if possible impose more transparent policies to protect the data of customers. The latter will help solve the problem from the root cause but may not be possible as it depends on the requirements of the government.

6. Participants' True Value of Anonymity

The following analysis relies on the raw data illustrated in figures D.6.1 and D.6.2. The figure used for analysis is figure D.6.3.

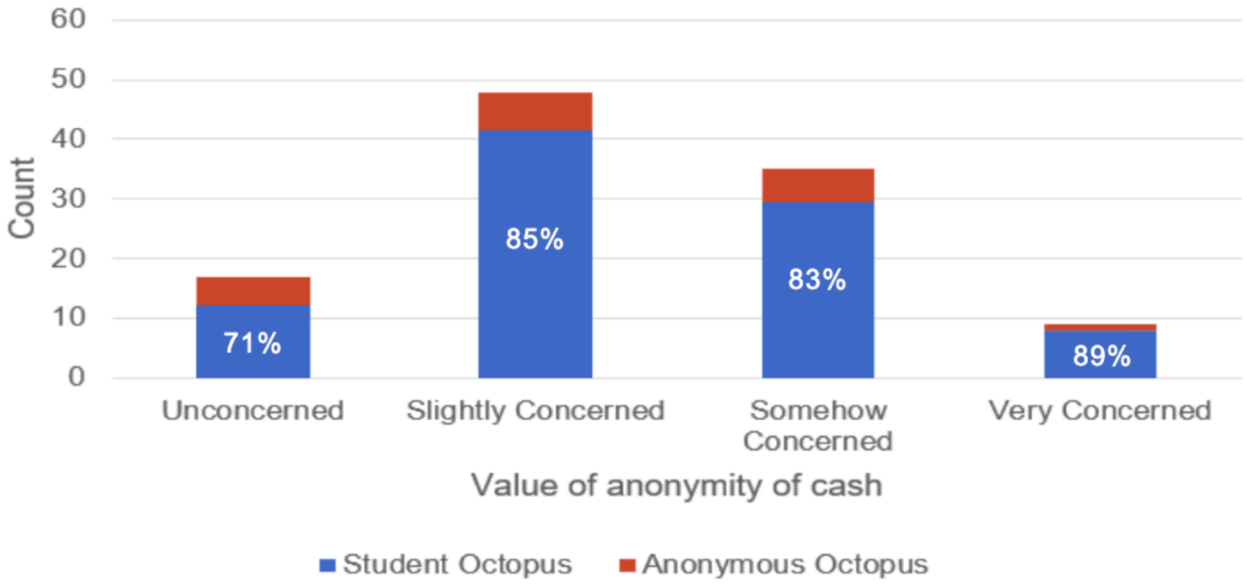


[Figure D.6.1: Is your octopus card registered with student status?]



[Figure D.6.2: Most governments can access the card or e-payment records of anyone, but they can't do the same for cash. How strongly do you value the invisibility / anonymity of cash payments?]

If a student values the anonymity of cash (Fig D.6.2), we would expect them to use an anonymous Octopus over a student-registered Octopus. As a student-registered Octopus is traceable by their student identity. However Figure D.6.3 below shows that this expectation does not match with reality.



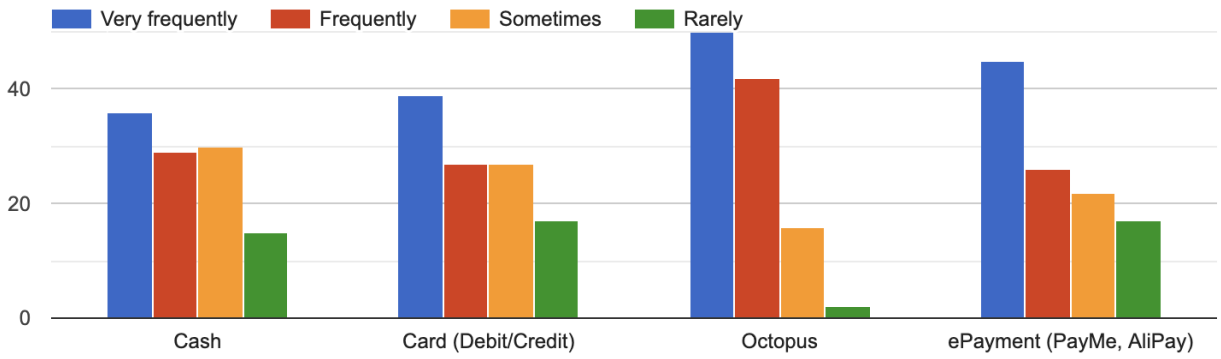
[Figure D.6.3: Student Octopus Registration Status and Value of Anonymity]

The result above shows that there's no difference in students' value of anonymity and the type of Octopus they use. In fact, people who are concerned the most about anonymity have the highest proportion of students using the student Octopus, which is not at all aligned with the expected result.

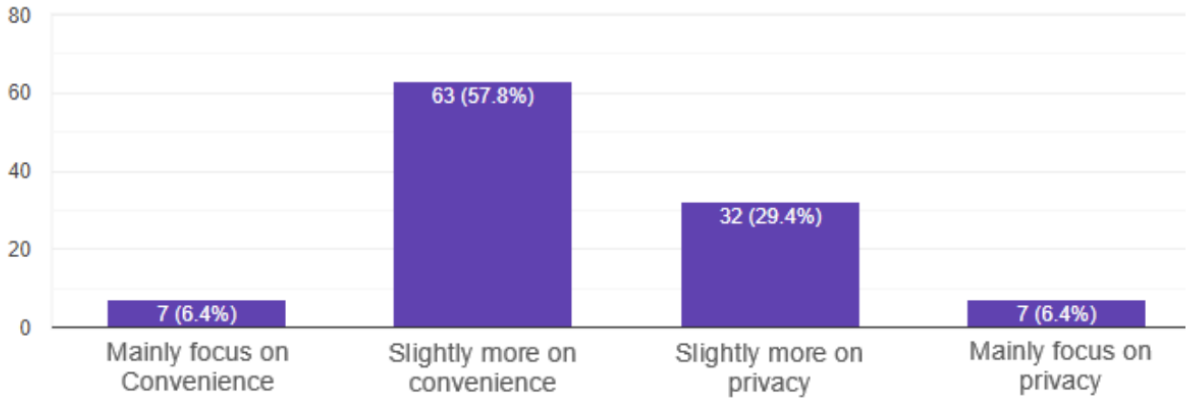
The statistical result above shows that there's little relationship between people's value in anonymity and their actual choice in octopus. It indicates that in the current stage, privacy is still not the major factor affecting people's payment choice, even though their answers in the survey indicate otherwise. This implies that survey results where participants are asked to give their opinion should be considered critically as beliefs may not align with actions.

7. Tradeoff between convenience and privacy and frequency of card use

The analysis in this section relies on the raw data collected in fig D.7.1 and fig D.7.2.

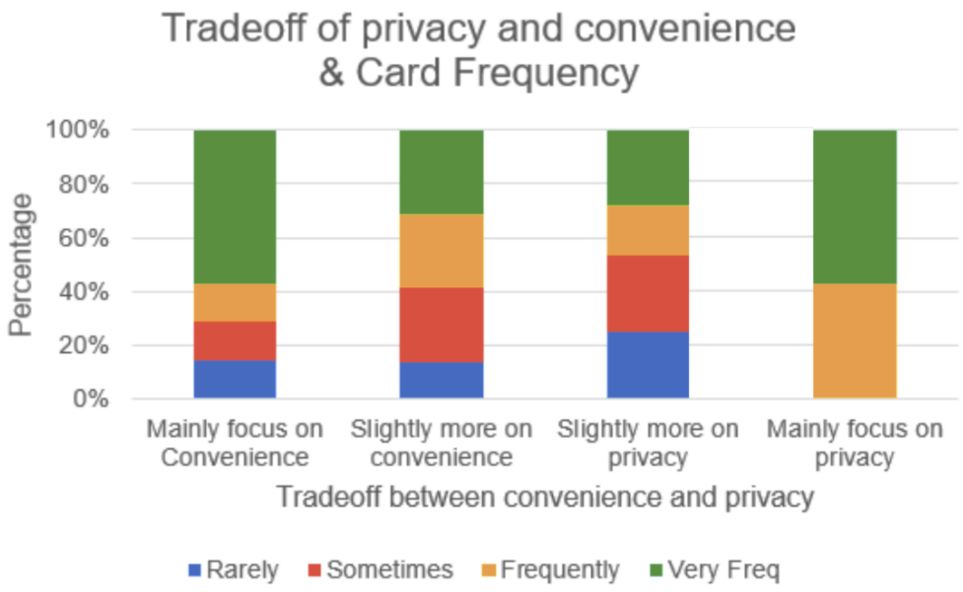


[Fig D.7.1: Please rank the payment methods you most frequently use for your average daily spending?]



[Fig D.7.2: There is often a tradeoff between privacy and convenience. Where do you place yourself on this spectrum?]

Combining the above figures for the *Card* payment method results in the figure D.7.3.



[Fig D.7.3: Tradeoff between convenience and privacy with frequency of card use]

It is interesting to note that the participants who value privacy over convenience (and hence selected *mainly focus on privacy*) are the more frequent users of credit / debit cards. This could mean that respondents place trust in card providers and believe their privacy is secure. Alternatively, it could place further doubt on the participants' answers on the tradeoff between convenience and privacy because, similar to section D.6, their actions do not align with their expressed opinions.

The next section uses rigorous hypothesis testing to explore the misalignment of actions and beliefs discussed in section D.6 and D.7.

Hypothesis Testing

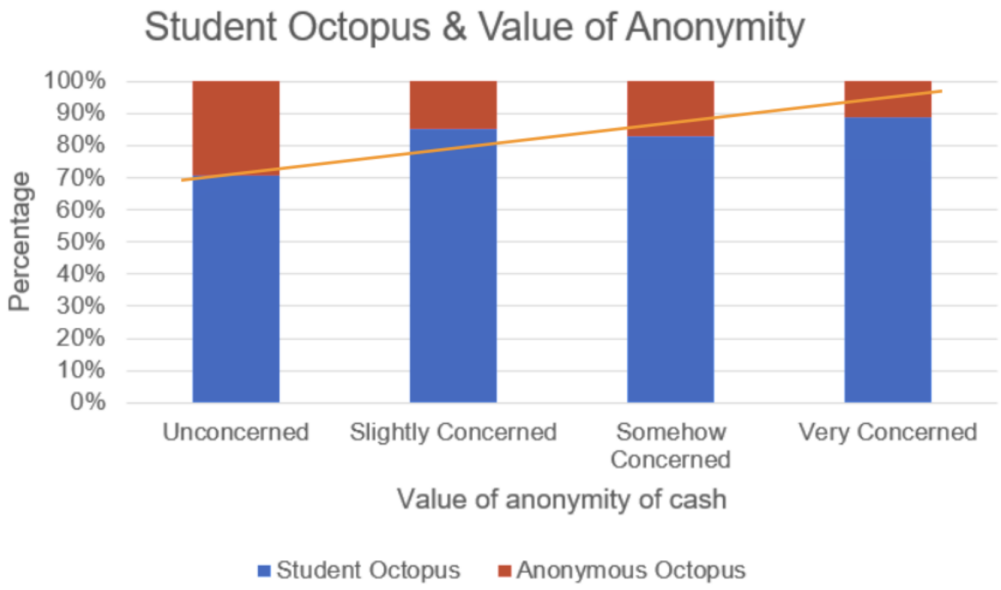
The key findings intuitively show the inconsistency between people's view on privacy and their actions. This section, Hypothesis Testing, aims to provide statistical evidence to the inconsistency argument from two aspects. The first one is students' value on privacy versus their choice on Octopus. The second one is value on privacy versus their payment preference, such as Cash, e-payment, etc.

1. Value on Anonymity Versus Choice of Octopus

Section D. 6 (about octopus registration and anonymity) argues that, from the "anonymity" point of view, the only difference between student octopus and adult octopus is anonymity. If privacy is the key factor

affecting students' choice of octopus, the number of choosing student octopus should be negatively correlated with their value on privacy.

However, by the percentage diagram below, there is a trend that the increasing value of anonymity leads to a surge of student octopus, which violates the previous argument.



[Fig. E.1.1 Students' Choice of Octopus vs. their Value of Anonymity (percentage)]

First, the crosstab of Choice of Octopus by Value of Anonymity is shown below.

Student Octopus (Y=1, N=0)	Value of anonymity 1	2	3	4	Total
0	**5**	**7**	**6**	**1**	**19**
1	**12**	**41**	**30**	**8**	**91**
Total	**17**	**48**	**36**	**9**	**110**

Pearson chi2(3) =	**2.2444**	Pr =	**0.523**
likelihood-ratio chi2(3) =	**2.0444**	Pr =	**0.563**
Cramér's V =	**0.1428**		
gamma =	**0.1876**	ASE =	**0.204**
Kendall's tau-b =	**0.0845**	ASE =	**0.093**

[Table E.1.1 Crosstab of Choice of Octopus by Value of Anonymity]

Here, the p-value of Pearson Chi-square test of independence is 0.523, which is directionless in relationship indication. Thus, regression analysis is needed.

Since one of the variables, “Choice of Octopus”, is binary, then logistic regression will be capable of testing the relationship between two variables above. Moreover, as the variable “Value of Anonymity” is categorical, then dummy variables are created to enable the regression process.

The regression formula is as follows.

$$Let\ p = Probability\ of\ student\ using\ Student\ Octopus,$$

$$x_2, x_3, x_4\ are\ the\ dummy\ variables,\ (x_1\ omitted\ to\ constant).$$

$$Logit:\ l = log_b \frac{p}{1-p} = \beta_0 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \beta_4 \cdot x_4$$

Null hypothesis:

$$H_0:\ \beta_2 = \beta_3 = \beta_4 = 0.$$

Alternative hypothesis:

$$H_1: \exists\ \beta_i \neq 0,\quad for\ i = 2, 3, 4.$$

The result of logistic regression is as follows.

```
Logistic regression                             Number of obs     =        110
                                                LR chi2(3)        =       2.04
                                                Prob > chi2       =     0.5632
Log likelihood = -49.598073                     Pseudo R2         =     0.0202
```

Octopus	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_IAnonymity_2	.8921932	.6712531	1.33	0.184	-.4234387	2.207825
_IAnonymity_3	.7339692	.6952218	1.06	0.291	-.6286405	2.096579
_IAnonymity_4	1.203973	1.186732	1.01	0.310	-1.12198	3.529925
_cons	.8754687	.5322906	1.64	0.100	-.1678018	1.918739

[Table E.1.2 Result of logistic regression on Octopus versus Anonymity (Dummy variable 2,3,4)]

In above result, zero falls into the 95% confidence interval of $\beta_i, i = 2, 3, 4$, showing no rejection to the null hypothesis. Hence, it provides an initial argument that **students’ value on anonymity is independent of their choice of octopus**. However, the independence is still not enough to prove the inconsistency argument of this section. Thus, the odds ratios are generated to support the statement.

Logistic regression — Number of obs = 110; LR chi2(3) = 2.04; Prob > chi2 = 0.5632; Log likelihood = -49.598073; Pseudo R2 = 0.0202

Octopus	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_IAnonymity_2	2.440476	1.638177	1.33	0.184	.6547913	9.095912
_IAnonymity_3	2.083333	1.448379	1.06	0.291	.5333164	8.13828
_IAnonymity_4	3.333333	3.955774	1.01	0.310	.3256345	34.12141
_cons	2.4	1.277498	1.64	0.100	.8455214	6.812364

Note: **_cons** estimates baseline odds.

[Table E.1.3 Odds Ratio of dummy variables in logistic regression]

First, omitting the dummy variable of "Unconcerned" in value of anonymity. The interpretation of odds ratio for dummy variable 2 (_IAnonymity_2) is the odds of students who are **Slightly concerned on privacy choosing student octopus** divided by the odds of students who are **Unconcerned on privacy choosing student octopus**. Since the odds ratios of dummy variables 2, 3, 4 all exceed one, then the larger value on anonymity leads to an increase of using student octopus, which is a violation of the assumption ("Students' choice on student octopus should be negatively correlated with their value on privacy").

Dependent variable: Octopus Equation: Octopus
Command: logit
Variables left as is: _IAnonymit~2, _IAnonymit~3, _IAnonymit~4

Value of anonymity	xb
1	.875469
2	1.76766
3	1.60944
4	2.07944

Key: xb = Linear Prediction

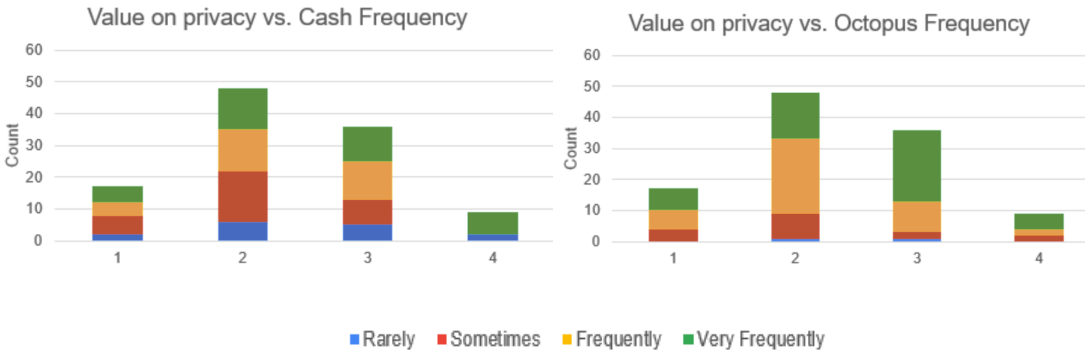
[Table E.1.4 Adjusted coefficient of 4 dummy variables of Anonymity in logistic regression]

After adjustment above, it is also clear that with the increase of students' value on anonymity, they are more likely to use student octopus. Even though the values of "Slightly more on convenience (2)" and "Slightly more on privacy (3)" are similar, it can be explained by different students' subtle understanding of privacy and convenience.

In overall perspective, the above hypothesis testing provides a strong argument to the **inconsistency of students' value on privacy versus their action** .

2. Value on Privacy Versus Payment Preference

Based on the visualization result in **section D. 7 (Privacy vs. payment frequency)**, the two diagrams intuitively show the trend of independence between students' view on privacy and their frequency in using Cash and Octopus.



1: Value on Convenience>>Privacy; 2: Convenience>Privacy;

3: Convenience< Privacy; 4: Convenience<<Privacy.

[Fig E.2.1 Value on privacy vs. Cash/Octopus Frequency]

Here, both variables (value on privacy and payment frequency) are discrete. Thus, the Pearson Chi-square test of independence is capable of finding the relationship between variables. Null and alternative hypotheses are as follows.

Null hypothesis:

$$H_0: \textit{Students' value on privacy is independent from their frequency of using cash.}$$

Alternative hypothesis:

$$H_1: \textit{Students' value on privacy is dependent on their frequency of using cash}$$

Frequency/Privacy	1	2	3	4	Total
Rarely	2 (2.32)	6 (6.55)	5 (4.91)	2 (1.23)	15
Sometimes	6 (4.64)	16 (13.09)	8 (9.82)	0 (2.45)	30
Frequently	4 (4.48)	13 (12.65)	12 (9.49)	0 (2.37)	29

Very frequently	5 (5.56)	13 (15.71)	11 (11.78)	7 (2.95)	36
Total	17	48	36	9	110

[Table E.1.1 Contingency table (actual count vs. expected count)]

$Degree\ of\ Freedom$: $df = (4-1) \times (4-1) = 9$; $Significant\ level$: $\alpha = 0.05$;

$Critical\ Value = \chi^2_{\alpha=0.05, df=9} = 16.92$; $Test\ Statistic = \sum_{i=1}^{r}\sum_{j=1}^{c} \frac{(O_{i,j}-E_{i,j})^2}{E_{i,j}} = 9.2852 < 16.92$

Since the test statistic does not fall in the rejection region, we cannot reject the null hypothesis. Therefore, we conclude that students' value on privacy is independent from their frequency of using cash.

Likewise, the test statistic of Octopus frequency is $12.6368 < 16.92$, showing the independence between students' value on privacy and their frequency of using cash.

Therefore, the hypothesis testing implies that **currently privacy is not the prior factor affecting students' payment preference on an overall perspective**.

Conclusion

There were several interesting discoveries that resulted from the research project. Firstly, it was discovered that there are certain key reasons for why students still use cash. The most important reasons include the fact that some merchants require cash and some students find that cashless methods have a risk of debt and credit build-up. Secondly, based on the survey respondents' payment methods, it is clear that Octopus and ePayment have already strongly established themselves as frequent payment methods. If a CBDC is deployed in Hong Kong, it should avoid competing with Octopus and ePayment as that will prevent CBDC from maximizing its market share. On a technological level, the survey showed that ability to make offline transactions is not a requirement for the Hong Kong customer, though citizens may *expect* this functionality as other CBDCs and some ePayment wallets have it. This shows a contrast to what was studied in the literature review of The Bahamas.

On a political level, the data suggest that the local youth population may be resistant to a CBDC if it is spearheaded by the government. Lastly, the hypothesis testing done showed that there is an underlying problem when asking participants to respond about their views on privacy. This is due to the phenomenon of social desirability, whereby participants will answer survey questions in a manner that will convey themselves as morally superior, even if that is not the truth. This was shown in the case of the value of anonymity and registered-Octopus usage, in addition to the privacy-convenience tradeoff and credit/debit card usage. Therefore, authorities should note that if they are to conduct future research, they must view them critically and not take the expressed opinions of individuals at face value.

Recommendation & Possible Implementations

Global Finance shows that over 73% of Hong Kong yearly transactions happened through debit/credit card (2020), while cash payment only takes 2% from the total amount. To avoid competition with Octopus and e-wallets, the CBDC should *integrate* with them rather than in place of them. The integration can be done in several ways such as permitting Octopus payments via the CBDC wallet, or allowing the CBDC wallet to act as an intermediary and transfer money to and from Octopus and ePayment wallets. CBDC can also act as an alternative in case that one of the payment channels crashes.

One of the key functionalities of CBDC is to enhance the financial inclusion of the society. Some may argue that the financial system is developed in Hong Kong and there should be less concern on financial inclusion issues. It is partially true that Hong Kong Monetary Authority (HKMA) reported over 94% of Hong Kong's residents having access to banking services (2020). This statistics correctly shows that for most Hong Kong adults, banking is no longer a concern. However, the focus group discussion conducted with the students indicates that youngsters and student associations are another "underbanked" group which is usually neglected from this plain statistics. The reason for youngsters' underbanking dilemma is usually caused by their parents' safety concerns and security requirements from banks. While the predicament for student association mainly comes from their ambiguous position in banks, between individuals and companies. For instance, if an association opens an individual account in banks, they have to transfer the bank account to their next executive committee. But account transfer can be tedious and hardly be done yearly in banks. While opening a companies' account, the minimum deposit requirement will hinder most newly-established student groups. The existence of CBDC provides an alternative to youngsters and student associations that may enjoy lower requirements of opening accounts as well as less functionalities, such as sacrificing credit consumption.

As reported by Global Finance, internet penetration is around 89% in Hong Kong 2020. The survey question about offline exposure also shows that internet crashes can hardly be the key reasons stopping people from using e-payment. Hence, the offline advantage of CBDC is unlikely to become a vital incentive for consumers switching to CBDC from their current payment preferences. While in light of the

mature technology of offline payment implemented in CBDCs, the functionality in offline usage can be a plus, but not a must facing Hong Kong's circumstance.

From the visualization result and hypothesis testing of the survey, convenience remains the key factor shifting students from one payment to another. Currently, octopus in Hong Kong is in the form of card tapping, and e-wallets usually adopt QR-code scanning. Inspired by e-Krona's implementation in Sweden, apart from mobile phone applications, CBDC can also be embedded in various wearable techniques, such as smart watches and cards. The increasing convenience may become another attraction for consumers to attempt CBDC.

As for privacy, the hypothesis testing shows people's inconsistency between their stated value on privacy and their action. One of the reasons is that consumers' view on privacy not only comes from the technology side. Plenty of the consumers won't go through the privacy policy carefully and would generally follow the crowds in the privacy assessment. This finding shows that apart from protecting privacy and anonymity technologically, market promotion is also important to establish a safe and reliable image of CBDC.

Furthermore, consumers from different cultural backgrounds are supposed to have different stereotypes across institutions. Hong Kong's current political environment suggests that a certain demographic of the youth may be averse to a government-led CBDC. A solution for this is to market the CBDC as an independent project from the government and if possible impose more transparent policies to protect the data of customers. The latter will help solve the problem from the root cause but may not be possible as it depends on the requirements of the government.

Future Work

- Limitations of survey

To further develop on the data collection and analysis done in this report, one can look to improve upon the participant demographics. Firstly, the sample size can be larger as that will greatly benefit the hypothesis testing. Though there is enough data to generate an intuitive understanding based on simple data exploration and visualization, there is still a large bias in the hypothesis testing.

Furthermore, as this research is focused on a Hong Kong-based CBDC, the survey respondent demographics should better reflect the population of Hong Kong. The biggest flaw with the demographic is that 30% of the respondents are Mainland Chinese students where Mainland Chinese only make up 12-25% of Hong Kong's population (varying figures based on source and definition). This means that the current data may have a slight bias.

Lastly, the methodology of the survey can be improved. As CBDCs are not well-known in the student population, this survey had to ask indirect questions and infer the sentiment of students. This can be improved by creating a prototype of a CBDC to give survey respondents, and then ask them more direct questions about the CBDC.

- Rapid market changes leading to timeliness of the report

In addition to the imperfectness of the survey, the timeliness of the report should be remarked. The rapid changes in Hong Kong financial market and global situation shift consumers' view on central bank digital currencies to a large extent. Due to network effects, consumers' may adapt to a new payment technology slowly at the beginning, while the process will be much accelerated after a period of time. Hence, the result and analysis shown in this report only stand for university students' general opinions on CBDC in early 2021. It can enlighten the current investigations while it is possible to be outdated because of the quick changes in the Hong Kong financial market.

- Future direction in CBDC

In mid 2021, HKMA proposed to restart the pilot study in Hong Kong retail CBDC, besides its Inthanon-Lionrock project in wholesale CBDC. It shows the gradual maturity of Hong Kong's market to accept the entrance of a new payment method. It is clear that the retail CBDC outperforms cash in efficiency and cost, and outshines e-wallets for its central bank-guaranteed security. Foreseeably, retail CBDC will eventually come into reality sooner or later. And now maybe it is time for Hong Kong.

Reference List

1. Adrian & Mancini Griffoli, A. M. G. (2019, July 12). The Rise of Digital Money. IMF. https://www.imf.org/en/Publications/fintech-notes/Issues/2019/07/12/The-Rise-of-Digital-Money-47097
2. Álvez, Lluberas, Ponce, M. A. R. L. J. P. (2019, April 1). The cost of using cash and checks in Uruguay. Banco Central Del Uruguay. https://www.bcu.gub.uy/Estadisticas-e-Indicadores/Documentos%20de%20Trabajo/4.2019.pdf
3. Bharathan, V. B. (2020, October 22). Central Bank Digital Currency: The First Nationwide CBDC In The World Has Been Launched By The Bahamas. Forbes. https://www.forbes.com/sites/vipinbharathan/2020/10/21/central-bank-digital-currency-the-first-nationwide-cbdc-in-the-world-has-been-launched-by-the-bahamas/?sh=196b06a3506e
4. Ossinger, J. O. (2021, April 19). Bahamas Tops China in Ranking of Central Bank Digital Currencies. Bloomberg. https://www.bloomberg.com/news/articles/2021-04-19/pwc-ranked-central-bank-digital-currencies-china-isn-t-number-1?fbclid=IwAR2h06AmpdCH4NDH9y5mZPAWi7
5. The Riksbank's e-krona pilot. (2020, February 1). Riksbank. https://www.riksbank.se/globalassets/media/rapporter/e-krona/2019/the-riksbanks-e-krona-pilot.pdf
6. Skingsley, C. S. (2016, December 30). Should the Riksbank issue e-krona? Riksbank. https://www.riksbank.se/globalassets/media/tal/svenska/skingsley/2016/tal_skingsley_161116_eng.pdf

Appendix

Appendix A: Survey Questions

https://drive.google.com/file/d/10uzLEMPaiIYRoKAXRCvesdGAkUQeKeRq/view?usp=sharing

Appendix B: Survey Raw Data

https://drive.google.com/file/d/17nqfT4mfXBsnxBKugsopTT46hv2pAcX4/view?usp=sharing