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Strengthening Supply Security in Future Economic Crises: Towards ICT-based Solutions for Distribution Problems

Martin Latzenhofer, Stephan Krenn, Stefan Schauer

Center for Digital Safety & Security, AIT Austrian Institute of Technology, Austria,
E-mail: {martin.latzenhofer, stefan.schauer, stephan.krenn}@ait.ac.at

Brigitte Allex, Christian Stefan

Directorate Spatial Statistics, Statistics Austria,
E-mail: {brigitte.allex, christian.stefan}@statistik.gv.at

Angel Gaydarov, Michael Scsepka

Center for Sustainable Production and Logistics, Fraunhofer Austria Research, Austria,
E-mail: {angel.gaydarov, michael.scsepka}@fraunhofer.at

The multiple, complex geopolitical and economic crises of recent years, such as the COVID-19 pandemic and gas shortages resulting from the Russian invasion of Ukraine highlight the need for national governments to address shortages of critical goods and services. This includes developing systems for their equitable allocation to specific population groups. Traditional ration coupon systems, such as post-World War II 'food stamps' proved to be inflexible and incompatible with demands of a modern information society. The Austrian research project 'e-Panini', a collaboration between public administration, federal states, interest groups, academia, and corporate partners, seeks to establish the necessary technical, legislative, societal, and organizational prerequisites for a modern ration coupon system leveraging information and communication technology (ICT). The proposed system enables continuous supply-side coordination of food, hygiene products, medicines, and other critical everyday goods. Its architecture integrates inventory management systems of major distributors, including grocery retailers, drugstores, and pharmacies to provide data on the spatial availability of these goods. The e-Panini system offers a differentiated and inclusive understanding of population needs, accounting for factors such as age, gender, occupation, health intolerances, and cultural or personal dietary preferences. By incorporating daily calorie requirements and other specific needs, it ensures a tailored and equitable approach to resource allocation. For end users, a mobile application-based system is envisioned to simplify deployment and enhance acceptance. To accommodate less tech-savvy individuals and ensure functionality during blackouts, alternative analogue participation options are included. While ICT integration significantly enhances system flexibility, it also introduces challenges, such as data protection, blackout resilience, pre-configuration for high-capacity demands, and offline operation with subsequent data synchronization. This article presents a conceptual architecture model for an ICT-based ration coupon system, addressing its content and technical challenges. It also explores potential solutions to ensure secure, efficient, and inclusive operation under various crisis scenarios.

Keywords: Supply Security, Critical Goods and Services, Ration Coupon System, Distribution Problem, Mobile ICT Application.

1. Introduction

In times of crisis, the uninterrupted supply of critical goods, such as food, medical supplies and energy to the population is essential. In many cases, this might not only be a logistics problem, but also an availability problem. Recent global health crises and geopolitical situations have taught us that shortages can happen quickly, without any warning. For example, the closure of borders and restricted mobility of workers during the COVID-19 pandemic affected the availability of food and other goods (Kakaei et al. 2022); excessive purchases and panic buying caused food shortages in supermarkets around the world (Sim et al. 2020; The Straits Times 2020). Similarly, the conflict between Russia and Ukraine affected energy and food markets: several European countries faced potential gas shortages (European Council 2024), and the impact on food security was felt in Europe as well as in developing countries (Leal Filho et al. 2023). Although in both examples, the availability of food and other products was never affected for a prolonged period, we can imagine situations where the purchase or receipt of critical goods needs to be regulated by governments to ensure an equitable distribution across the population.

One way of doing this is to introduce a ration coupon system (i.e., "food stamps"). Such systems were widely used after World War II and can be found in several parts of the world, such as Austria and Germany (Kulshrestha 2010), Britain (Booth 1985), but also Australia (Froude 1999). However, the concepts of that time do not take into account the needs and expectations of today's society: the variety of products is much greater, dietary restrictions and personal lifestyle choices (e.g., vegan diet) are much more common, and various restrictions due to religious laws and practices need to be considered. In addition, paper-based ration coupon systems would be more complex to distribute and could be easier to counterfeit or manipulate these days.

A digital solution could solve several of these problems and, due to the increasing digitalization over the past decades, digital devices such as smartphones or tablets are widely available to the population. Hence, the development of a digital ration coupon system would be a natural next step to facilitate the distribution and delivery of critical supplies in crisis situations.

In this article, we present the reference design of a ration coupon systems, mainly based on an Information and Communication Technology (ICT) solution, which can be used to implement the seamless coordination and distribution of such critical goods such as food, hygiene products or medicines. In particular, the solution is working on a calorie-based allocation model that covers the daily requirements of people of different ages and gender. The solution is also able to take into account occupational demands, dietary restrictions and preferences, as well as religious practices. As a result, the solution is highly adaptable to the specific needs of different segments of the population, as well as to different crisis situations and shortage scenarios. From a technical perspective, the solution is designed to be easily accessible via mobile phones, but also provides a paper-based solution for people who cannot use digital devices or in situations where power or communication are not available. The solution is also designed to be integrated with the ICT systems of supermarkets, pharmacies, and other shops, both to provide an overview of product availability and to be linked to their cashier systems to create a harmonized purchasing process. In general, the e-Panini solution is designed to remain dormant during normal periods (with infrequent updates of the underlying data) and to be quickly activated in the event of a shortage or crisis phase.

The remainder of the article is structured as follows: in the next section, we provide an overview of the study design and the process concepts behind our solution. Section 3 focuses on the technical design and high-level architecture we envision for the ration coupon system. In Section 4, we discuss some of the challenges that we faced during the design process, particularly in the areas of privacy, authentication, and availability, as well as allocation and the process model. Finally, Section 5 summarizes the findings and provides an outlook on the next steps in the e-Panini project.

2. Approach

2.1. Study design

An overarching **project structure** was created to ensure a comprehensive approach to concept development, incorporating as many different perspectives (hereafter referred to as streams) as possible. These individual streams allowed specific detailed questions from experts in the project team to be discussed and the best possible practical solution proposal to be formulated. This also enabled a large consortium to carry out the project tasks in the most resource-efficient way.

The ***People*** perspective looked at the issue of a ration coupon system in a situation of economic shortage from the perspective of the people affected. The term 'people' thus encompassed all the addressees of the ration coupon system - i.e., all the stakeholders (population, authorities, etc.) who are intended to benefit from the system and its services, or who play a role in the process.

Stream ***Process*** captures the basic processes of the concept in a rough form depending on the current phase, e.g., normal case, special case, adjustment of the basic quantity, exchange economy, intersection of data sources and the organizing collective actors involved.

Stream ***Partners*** assessed the current situation in other European countries - whether a digital ration coupon system is planned or already in operation, in what form and for what applications. It was also discussed in what form external data connections are useful, e.g., logistics, distributors, reporting registers, and plausibility checks.

The ***Products*** stream adopted a classic technical perspective to conceptualize the desired ICT system, its processes and communication lines between the technical components. Finally, data flows were analyzed according to life cycle phases, data structures and communication sequences.

As the legal considerations were very comprehensive, Stream ***Politi*** was designed as an open discussion platform for public administration. The objective was to discuss the current legal framework conditions, to analyze the existing legal situation and to identify the potential need for policy changes.

The ***Program*** stream was set up on the results of Stream Products and was ultimately responsible for the implementation of the demonstrator, i.e., de facto the coding.

2.2. Process conception

For a successful ICT reference system, organizational and procedural aspects need to be considered (Oyetade, Harmse, and Zuva 2024) from the planning stage. This includes strategic, tactical, and operational levels in public administration and private stakeholders. Responsibilities and tasks should be clearly defined. Early identification and integration of technical advancements and changes in organizational and communication structures are essential (Phillips and Klein 2023) and is ensured by specific processes.

For process development, collective actors such as the population, authorities, political level and expert panel, companies from production and trade, and ICT system administrators are defined in order to allocate tasks. The definition of stakeholders (McGrath and Whitty 2017) (Benes and Groh 2022) is necessary to link strategic, tactical, and operational management levels across sectors. **Stakeholders** are described below.

Population refers to all the people living in a given geographical area. The term includes all ages, genders, ethnicities, and social classes.

Authorities are government or municipal institutions that perform public tasks and administrative functions. They have the power to issue binding legal acts, make orders, and, where necessary, enforce them.

The ***political level*** includes federal, state, district, and municipal governments responsible for legislation and its

implementation. They work closely together on political decisions.

Expert panels of specialists provide advice, analyses, and recommendations to support policy makers.

Manufacturing and trading companies include a range of businesses involved in production and distribution. They play a key role in the economy by producing, processing, and selling goods to consumers and other businesses.

ICT staff like system administrators, developers, network engineers, and support personnel work together to ensure the system's functionality and security. An ICT system includes the hardware, software, and network infrastructure used for data processing, storage, and transmission.

In order to address a crisis effectively, a universally applicable **process model** has been developed. This comprehensive process concept consists of seven phases, shown in Figure 1. The concept is designed as a loop, with the individual phases handled sequentially.

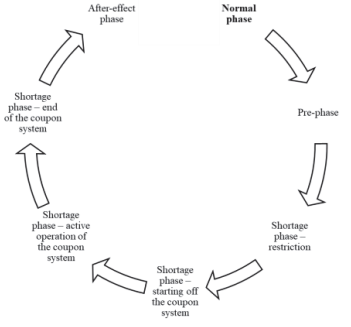

Figure 1. Phases of the designed process concept

Normal phase: Operations and activities occur under standard conditions without any special restrictions or adjustments.

Pre-phase: The transition to a potential shortage phase begins, marked by early signs of resource scarcity or emerging challenges. Preparations are initiated to address potential disruptions.

Shortage phase – restriction: Resource shortages intensify, prompting the implementation of initial restrictions. Measures focus on reducing consumption and optimizing the use of available resources.

Shortage phase – starting off the ration coupon system: The ration coupon system is introduced to regulate access to scarce resources and ensure equitable distribution. Planning and communication are critical to achieving public acceptance and understanding.

Shortage phase – active operation of the ration coupon system: The ration coupon system is fully operational, with strict controls on resource distribution. The system's effectiveness is continuously monitored and adjusted as needed to meet objectives.

Shortage phase – end of the ration coupon system: This marks the beginning of the withdrawal from the shortage phase, where the ration coupon system is gradually dismantled as the resource situation improves. Careful planning is needed to ensure a smooth transition back to normal operations.

After-effect phase*:* The impacts of the shortage phase are analyzed and evaluated. Insights and experiences are gathered to improve future processes and strengthen resilience against similar challenges.

These phases provide the foundation for effective crisis management. Each phase is divided into subordinate process steps, triggered by start events and concluded by end events. Clear assignment of tasks to specific actors ensures efficient and transparent handling of responsibilities during crises.

In terms of engagement, most process steps are assigned to the *authorities* and *ICT staff* in each phase of the process concept. This involvement is crucial for monitoring potential shortages, implementing regulatory interventions if required, establishing and managing the ration coupon system, and subsequently transitioning back to the normal phase. The involvement of *expert panels* and *manufacturing and trading companies* extends to all phases, though to a lesser extent than that of *authorities* and *ICT staff*. The *population* is only included from *shortage phase – starting off the ration coupon system* onwards, as they must become active from this point onwards to utilize the ration coupon system.

2.3. Allocation model

The Austrian Federal Ministry's "List of Critical Goods" (internal reference) identifies essential items required for effective crisis management, including food, medical supplies, energy sources, and agricultural inputs.

Based on the list of critical goods the e-Panini project designs a calorie-based allocation model to distribute food resources efficiently during emergencies. The model accounts for the daily calorie requirements of individuals, with an average adult need set at 2,000 kcal per day. Specific age- and gender-based calorie needs range from 1,700 kcal (children) to 3,000 kcal (active males) (Stehle and Ellinger 2024). This allocation is distributed among food groups to ensure a balanced diet (Sturm et al. 2024):

- 40% from cereals and potatoes
- 23% from animal products such as meat, fish, eggs, and dairy
- 13% from vegetables and fruits
- 10% from fats, oils, and seeds
- 3% from pulses

The e-Panini allocation model operates in three stages, each designed to address specific population needs and logistical challenges during crises. These stages are modular, allowing the system to scale and adapt depending on the severity of the crisis and the resources available.

2.3.1. Level 1: basic module

This module is intended to act as the backbone of the allocation system, providing immediate relief and establishing a framework for more specific adjustments in subsequent stages. All recipients receive the same calorie allocation grouped by a simple classification of age and

gender, ensuring no one is deprived of basic nutrition (Table 1).

Table 1: Daily calorie allocation (kcal/d) by age group and gender (Level 1)

AGE	GENDER		BASE VALUE
	Male	Female	
0-10 years	1,800	1,700	1,700
11-19 years	2,600	2,400	2,400
> 19 years	2,400	2,200	2,200

2.3.2. Level 2: demographic and vulnerability considerations

Building on the basic module, this stage introduces tailored calorie allocations to meet the unique needs of different demographic groups and individuals with heightened vulnerability. This module emphasizes inclusivity and precision by considering:

Age-specific needs. Children, adolescents, and elderly individuals have different caloric and nutritional requirements due to their varying metabolic rates and physiological needs (see Table 2).

Table 2: Daily calorie allocation (kcal/d) by age group and gender (Level 2)

AGE	GENDER	
	Male	Female
1–7 years	1,800	1,700
8–10 years	1,900	1,800
11–16 years	2,600	2,400
17–19 years	3,000	2,400
20–51 years	2,700	2,200
52–65 years	2,500	2,200
> 65 years	2,400	2,200

Pregnancy and lactation. Pregnant and breastfeeding women require additional calories to support fetal growth and milk production.

Occupational demands. Individuals engaged in heavy labor are allocated additional calories to match their energy expenditure (see Table 3) (Stehle and Ellinger 2024).

Table 3: Daily calorie allocation (kcal/d) according to "Physical Activity Level (PAL)"

Physical Activity Level (PAL)	GENDER		Description
	Male	Female	
1.8 – 1.9	2,700	2,200	Standing activity
2.0 – 2.4	3.200	2.700	Physically strenuous activities

2.3.3. Level 3: dietary restrictions and preferences

The final stage refines the system further by incorporating cultural, religious, and personal dietary considerations. This ensures that the allocation system respects diversity and promotes acceptance among recipients. The main aspects include:

Religious practices. Specific dietary laws, such as the avoidance of pork for Muslim recipients or the need for kosher foods, are integrated into the food distribution model.

Lifestyle choices. Preferences for vegetarian or vegan diets are accommodated by adjusting the composition of the allocated food items.

3. Technical Design

With the relevant system actors and core allocation model requirements identified, this section provides a high-level overview of the e-Panini ration coupon system.

3.1. Reference systems

The initial design decision focused on the form of the system, drawing from three established models used in other applications:

(i) 'Ticket Shop': Assets are stored centrally or multi-centrally in a backend system. Access is via smartphone, with distributors contacting the central data storage. This model requires extensive digitalization of the population.

(ii) 'Electronic wallet': Assets are stored in a decentralized manner on a special card. Access is via card readers at distributor points.

(iii) 'Paper': Assets are printed on paper and used as authorization for purchase. This model serves as a backup option for blackouts or sustained communication disruptions.

While the paper-based model (option 3) ensures the highest availability during large-scale electricity outages, it was designated as a fallback solution to leverage the advantages of ICT-based systems. Ultimately, a mobile application-based system (option 1) was chosen for its superior integration with retailer checkout systems, flexibility in adapting to user needs, and robust management of contingencies like theft or loss. However, real-time communication at checkout posed additional challenges, discussed in subsequent sections.

3.2. High-level architecture

An overview of the e-Panini ration coupon system is given in Figure 2, which is described in more detail below. Note that this discussion focuses mainly on the functional flow; selected choices for security and backup strategies are discussed in the following section.

The system was designed in a user-centric way, as community acceptance is key for an ICT system designed for challenging situations such as food shortages.

Users have a mobile application, for which they need to register once using a government electronic identity; or alternatively they can seek assistance from local administrations, such as local town halls. This registration can be done well in advance, e.g., during the normal phase or Pre-Phase, to avoid server overload and to familiarize the user familiar with the system. The account management options also include an option to specify "subscription

households". This is a group of citizens who can pool their rations so that each of them can claim the goods. This is important for families or (informal) life partnerships from a usability point of view. Subscription rights can also be assigned to external users as well (e.g., to cover cases of legal guardianship).

Once registered, citizens can use their application at any checkout of a distribution point (indicated by the green steps in Figure 2). To do so, they simply present, for example, a quick response (QR) code generated by the application to the cashier, who scans the code using the checkout terminal. The next steps are the same as when redeeming a bonus from a loyalty programs: the distributor validates the QR code and forwards the procurement to the backend system, which manages the balance for each specific user. If the balance is positive, the system responds in real time, and the payment process continues, otherwise it is cancelled.

Note that this design also relieves the cashier of any manual interaction to validate authorizations, as they only need to scan a code. This has at least two advantages: firstly, it reduces the risk of coercing a cashier, as they cannot influence the authorization process. On the other hand, it also eliminates the need for unfamiliar actions in a stressful situation, as they only need to scan a mobile application, as is the case with many loyalty programs.

Another important role in our system is played by local administrations. They have certain system administration rights in the sense that they can generate paper-based QR codes, e.g., for elderly or less tech-savvy users. They can also register users without legally binding electronic identities, including unregistered homeless people. To prevent abuse, their rights are strictly regulated, and all their activities are logged by the system in a verifiable way.

To support decision makers at tactical and policy level, the backend system provides continuous reporting interfaces (e.g., on spatial distribution of subscriptions, specific needs per commodity, etc.). Together with reporting from distributors and external sources (national statistical offices, producers, etc.), this improves the overview of the situation and allows informed decisions to be taken at all levels involved.

By using an ICT-based system, decision-makers can dynamically adjust the rations allocated to different user groups, according to supply and demand. These rations are periodically (e.g., weekly) posted by the backend system to all user accounts. To prevent stockpiling, maximum amounts (e.g., equivalent to three weeks' rations) are provided.

Finally, the design of the e-Panini ration coupon system also covers the important aspect of subsidies. Depending on the specific situation, a ration coupon system can authorize the user to buy a product at its regular price, or to buy a product at a fixed (defined) price. The latter is particularly important in the case of essential goods, where black markets may develop. In this case, different groups of citizens may receive different amounts of subsidy at the government level, e.g., depending on their age, income, or social situation. In this case, e-Panini also tracks the amount paid as well as the regular retail price, allowing authorities and distributors to obtain accurate and up-to-date figures on compensation payments.

4. Challenges and Design Choices

4.1. Privacy, authenticity, and availability

Building an ICT-based ration coupon system for crises with unpredictable constraints presents a number of technical design challenges, which we briefly discuss below.

Temporary grid outages. While long-term and large-scale electricity blackouts are outside the scope of an ICT-based system by definition, (temporary) network failures may occur. In such a situation, modern point-of-sale terminals are able to cache transaction data internally for later communication to the backend infrastructure (while payments have to be made in cash), cf. the red steps in Figure 2. However, users could try to use such unsynchronized states between points of sale to overspend their actual budget, as there is no real-time verification of their balance can be carried out. Like a bank account, upon

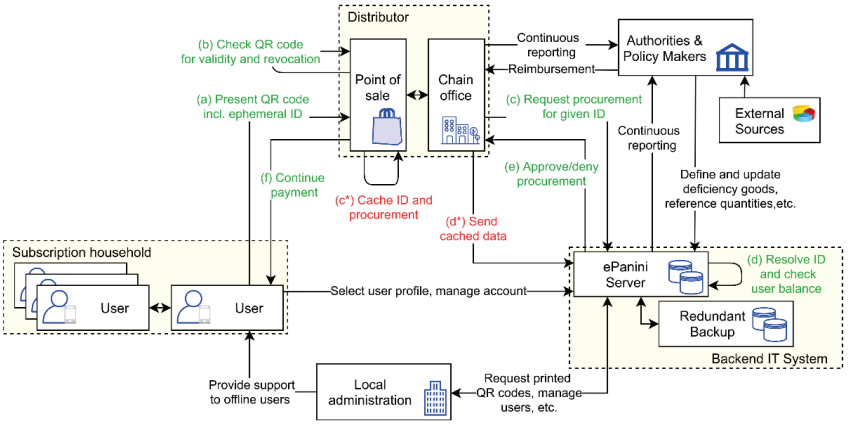

Figure 2: High-level overview of the e-Panini ration coupon system

re-synchronization, the backend ICT system would show a negative account balance for the user, which would be counted against when the next allotted rations are posted.

Authenticity and revocation of subscription authorizations. The authenticity of subscription tokens (e.g., QR codes) for a specific user account is easy to verify in an online environment. However, to provide protection in offline scenarios, such as network outages or paper-based tokens, e.g., for the elderly, all tokens must be digitally signed by the authority. In the case of lost or stolen printouts, efficient revocation mechanisms must be in place. In our architecture, this is realized by blocklists of token identifiers that the terminal checks against in real time. In addition, these blocklists are periodically retransmitted to the terminals to enable revocation checks even in the event of network outages. Finally, all tokens are encoded with an expiration date.

User profiling and data minimization. Privacy-by-design is a key principle to be followed in the development of any ICT-based system, and even more so for systems that are citizens are required to use in times of crisis. Risks to be mitigated include, e.g., that points of sale could (re-)identify users depending on the information contained in the tokens. While re-identification is impossible with paper-based tokens (the same token can easily be detected), tokens generated in the mobile application do not contain any personally identifiable information, but only token identifiers agreed upon between the user and the backend system. Tokens are ephemeral and generated per transaction, so that no (re-) identification is possible.

Another issue is the tracing of users by the ICT backend. In order to overcome this, supermarket chains act as "mixers", so that both the points of sale and the backend service receive only the information they ultimately need to provide their services: the point of sale learns what quantities of which products are purchased when and where, but does not learn any information about the user beyond a random one-time token identifier – i.e., the same information as during a normal purchase process. On the other hand, the backend service only receives information about how much of the underlying deficiency-managed good was sold by a user when and in which supermarket chain, but neither the exact location nor the specific product – i.e., only the information needed for accounting purposes. The use of completely anonymous solutions such as privacy-preserving e-cash (Chaum, Fiat, and Naor 1990) (Baldimtsi et al. 2015) was analyzed but withdrawn due to efficiency considerations and a lack of functionality in case of fraud.

Availability. The proposed architecture also includes recommendations to minimize single points of failure in order to strengthen availability and thus reliability. These include for example redundant storage of all user and account data at independent locations, and uninterruptible power supplies. Furthermore, proper pre-configuration of households and user demands based on, e.g., statistical data will help to minimize availability problems when the system is first activated, due to too many parallel user accesses.

Eating out. By definition, an ICT-based ration coupon system inherently requires a certain degree on digitalization on the distributor's side, which limits its applicability in the case of eating out. However, commercial kitchens (e.g., company canteens) usually have the necessary ICT infrastructure, such as check-out terminals, so that an integration into the e-Panini system is possible by defining the amount of deficiency good per meal. The case of absences, e.g., due to time spent in hospitals or prisons, can be covered by granting subscription rights to these institutions (cf. above). Meals in school canteens or kindergartens are deliberately not taken into account due to the particular vulnerability of these user groups. Finally, eating out, e.g., in restaurants without ICT infrastructure, is not supported by the system, yet is considered unessential in case of severe food crises.

4.2. Allocational Aspects

In crisis situations, it cannot be assumed that all beneficiaries will act rationally or in the public interest. To mitigate the risk of abuse, technical safeguards are embedded into the system's design. These safeguards use structured data to perform automated plausibility checks.

Key demographic attributes, such as age or gender are cross-referenced with the central civil register (i.e., the Austrian *Zentrales Melderegister* (ZMR), a dynamically updated database maintained by the Ministry of the Interior). The ZMR contains essential individual-level information on all Austrian citizens and residents, including date and place of birth, nationality, sex and address. This data enables plausibility checks to ensure that food and resource allocations are accurate and resistant to misuse during emergencies.

Furthermore, additional databases facilitate the implementation of plausibility checks, thereby increasing overall accuracy of the system. For instance, the use of:

- Statistics on pregnancy and lactation ("parents and baby book")
- Statistics on occupational demands

By integrating data from these sources, the e-Panini system ensures transparency and equity in resource distribution. Automated checks reduce the administrative burdens while maintaining the reliability and integrity of the allocation process, even in challenging crisis scenarios.

4.3. Training and sustainability

A key challenge for any ration coupon system is that, in the best case, it will only be used in the distant future, if at all. Therefore, a central issue is that when required, the current decision makers will not be in office anymore, and designers and developers may not be available either, which indeed was one of the reasons for initiating the e-Panini project in the first place. An additional challenge for an ICT-based system is that any software stack is likely to be outdated by time of deployment.

In order to overcome this challenge, the e-Panini solution was designed with sustainability in mind. In fact, we identified related scenarios that, while very different in motivation and user perception, face similar challenges, and could therefore benefit from our ration coupon system. Besides amortizing implementation and maintenance costs, this has the additional benefit of detecting implementation

and design flaws early, with a potentially smaller user group. Furthermore, citizens would already be used to the system, further increasing social acceptance in case of need.

One possible application is social cards, which allow entitled persons (e.g., people on low incomes or asylum seekers) to purchase food within a certain quota with financial support from the federal government on presentation of the card. Another example could be tourist cards, which provide the holder discounted admission to tourist attractions. We believe that identifying partners for such long-term deployments is of utmost importance for any sustainable ration coupon system.

Besides these aspects, proper documentation, regular seminars, and also (interactive) simulation games involving all relevant stakeholders will be important to minimize frictions in communication and optimize processes across all entities.

4.4. Process model

Managing processes requires detailed analysis and step-by-step modelling to improve clarity. Alignment with stakeholders requires clear communication channels and regular meetings to strengthen cooperation. Continuous development is ensured by implementing a flexible process model that allows for regular reviews and adjustments (Butt, Naaranoja, and Savolainen 2016) (Benes and Groh 2022).

Effective communication is vital, which is achieved through comprehensive documentation and training sessions, ensuring all stakeholders have clear tasks. Data integration also requires using analysis and visualization tools to adapt processes to regional requirements. Ensuring compliance requires regular review and updating of the process model.

By expanding processes with detailed information, effectiveness and clarity are improved. This includes specifying important information such as the interfaces between databases, the systems used, and the participants involved in each process step (Wynn and Clarkson 2018). For instance, detailing the interfaces of databases helps in understanding how data flows between different systems, ensuring data consistency and integrity. Aiming for better planning and resource allocation, specification of the systems used in each process step is added. This ensures that the necessary tools are available and functioning correctly.

Overall, including these details in process documentation helps in creating a comprehensive and transparent process model. It facilitates better communication, coordination, and execution, ultimately leading to more effective and efficient operations.

Creating detailed documentation (Ungan 2006), conducting regular workshops and feedback sessions, ensures that the process steps are carried out in a good and comprehensible order. In order to allow all stakeholders to provide their important input in the creation of a process, it is necessary to organize the individual steps in joint consultation sessions (Leventon et al. 2016). By addressing these challenges and implementing the proposed solutions, an effective and flexible operational process concept for the ICT system is developed.

5. Conclusions

The information obtained from the proposed ICT-based coupon ration system in combination with data from the distribution centers, e.g., from warehouse management systems, provides decision-makers with a comprehensive database for fact-based measures to ensure security of supply. In particular, the digitalized solution provides the authorities with a better real-time situational awareness picture of the actual supply situation in the country, which they can respond to by dynamically adjusting the allocation of scarce goods and services. In addition, targeted distribution can be further optimized by taking account of people's different needs – such as food intolerances or cultural requirements such as vegetarianism. In this way, the system contributes to optimizing the resilience of the population in times of economic shortage.

The system was designed having Austria's needs in mind – but most of the concepts and design decisions are applicable to many other countries. As previous project analysis has shown that hardly any countries have ICT-based systems (or others) in place, we hope to speed up also the design process in these countries as well.

An ICT-based ration coupon system, which was implemented as a central online version, can only be used sensibly if information and communication technology is not part of the crisis situation.

The online version offers clear advantages in terms of being able to react flexibly to changing requirements (e.g., different utilization profiles, requirements depending on occupational groups, incompatibilities) during an economic shortage and to distribute the available quantities of goods in the best possible way.

Where possible, the ICT-based ration coupon system should be used on an ongoing basis by a smaller group of recipients – e.g., rationing for social markets, benefits in kind for disadvantaged population groups, discounted visits to tourist destinations, etc. – in order to ensure that it is technically and organizationally highly likely to work for the entire population of a country within a short period of time in a crisis. Pre-integration of the purchase authorizations into the checkout systems of large issuing points such as supermarkets is recommended.

Such an ICT-based ration coupon system should be developed in accordance with the security-by-design principle, as there is a major impact in the event of security incidents from a data protection perspective. Nevertheless, the system should be able to buffer if there is no online connection. It should also be possible to overdraw the subscription authorization and receive less credit in the coming period.

There are high requirements before using the ICT-based ration coupon system in an economic shortage situation. This should be kept as short as possible to limit uncertainty among the population. This concerns the parameterization, e.g., mapping of certain goods into a shortage goods category, preparation, and creation of the legal regulations by the public administration and politicians, roll-out of the smartphone app, registration, profile selection, reference household formation, etc.

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