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Market Potential Estimation Framework for Circular Economy

Ziqing Wu * Raphaël Oger * Matthieu Lauras *
Benoit Montreuil ** Louis Faugère ** Aymeric Libeau ***

* *Centre Génie Industriel, IMT Mines Albi, Université de Toulouse,
Albi, France (e-mail: first.last@mines-albi.fr)*

** *Physical Internet Center, ISyE School, Georgia Institut of
Technology, Atlanta, USA (e-mail: benoit.montreuil@isye.gatech.edu,
louis.faugere@gatech.edu)*

*** *Transition-One, Orléans, France (e-mail:
alibeau@transition-one.fr)*

Abstract: Circular economy brings environmental, economical and social benefits to the society. New business initiatives are encouraged to accelerate the shifting towards a circular economy. However, the scaling of new business in the circular economy is still under-researched. This study is focused on the demand aspect of business scaling, and aims to propose a holistic framework to estimate the market potential for a new business in the circular economy. The framework is composed of sets and filters, where demand forecast is deduced from the statistics of existing products and secondary market research. Quantitative and qualitative methods are both used in the framework, where clustering analysis and multi-criteria decision-making techniques are combined with expert judgement. A case study on electric retrofit of vehicles is proposed to demonstrate the application of the framework.

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Keywords: End-of-Life Management and the Circular Economy, Social and Environmental Sustainability, Supply Chains and Networks, Forecasting, Decision Support Systems

1. INTRODUCTION

As reported by Intergovernmental Panel on Climate Change (IPCC) in April 2022, limiting global warming to 1.5 °C will be impossible without sweeping changes. Circular Economy, defined as “a regenerative system in which resource input and waste, emission, and energy leakage are minimised” by Geissdoerfer et al. (2017), can contribute significantly to the mitigation of global warming. Shifting towards a circular economy brings not only environmental benefits, but also better GDP, social welfare, and industrial renewal (Ellen MacArthur Foundation, 2015).

The concept of circular economy incorporates various notions, among which one can cite reuse, repair, refurbish, remanufacture, recycle, etc. (Geissdoerfer et al., 2017). The business actions that can be conducted under circular economy are recapitulated as so called ReSOLVE framework by Ellen MacArthur Foundation (2015). ReSOLVE stands for regenerate, share, optimise, loop, virtualise, and exchange. These actions improve resource utilisation, extend the lifetime of physical assets, and encourage the use of renewable materials. They serve as levers for private and public organisations to contribute to a circular economy.

ReSOLVE framework is a tool for companies to create new business initiatives, by choosing or combining the six actions. New business initiatives are highly encouraged to foster the implementation of a circular economy. While having an idea is far from enough to achieve an effective commercialisation, six questions shall be asked according

to Aulet (2013) while launching a new business: Who is your customer? What can you do for your customer? How does your customer acquire your product? How do you make money off your product? How do you design & build your product? How do you scale your business?

Among these questions, business scaling is essential for companies to gain more profits and enlarge their societal impact. In a more general context, scaling is seen as a key component for sustainable management and thus indispensable for the democratisation of a circular economy (Breaugh et al., 2021). To tackle with business scaling, demand and supply aspects shall be both considered, thus two subquestions can be furtherly derived: How to estimate the market potential for a new business in the circular economy? How to design and deploy the supply chain network for a new business in the circular economy?

The focus of this paper is on the demand aspect of business scaling. Different from sales forecast, which predicts future sales from past data, demand forecast predicts customer willingness to purchase a product and is independent of any supply constraints. We aim to propose a holistic framework to estimate the market potential, thus to conduct the demand forecast for a new business positioned in the circular economy. While a new business in the circular economy is often linked to sharing, reusing or improving existing products, the complexity due to the high variety of a specific type of products shall be considered. Furthermore, the market potential estimation shall explicitise the

geographical disparity, to facilitate the market deployment planning and supply chain network design.

The rest of the paper is organised as follows. Section 2 reviews the related work and introduces the contribution of this paper. Section 3 presents the proposed framework for market potential estimation. Section 4 shows a case study on electric retrofit business of passenger vehicles to illustrate the application of the framework. Section 5 concludes the paper and proposes perspectives.

2. RELATED WORK AND CONTRIBUTION

This study is at the crossroads of three disciplines: entrepreneurship, new service forecasting and market selection. The research gaps are identified by analysing the limitations of these disciplines in estimating market potential of a new business in the circular economy. In addition, the contributions of this study are outlined in this section.

O'Reilly and Binns (2019) divide disruptive innovation into three phases: ideation, where ideas are generated for the creation of a new business; incubation or the validation of valuable ideas in a beachhead market; scaling, where growth of a new venture is assured. They argued that scaling is essential to the new venture's success while it is much less studied than ideation or incubation. Existing entrepreneurship methodologies often include recommendations about how to scale a new business. Disciplined entrepreneurship (Aulet, 2013) underlines the calculation of total addressable market for the beachhead and follow-up markets, by top-down or bottom-up approaches. Bottom-up analysis counts the potential customers directly, thus it is more accurate and realistic than the top-down one using secondary market research. The former can also localise each potential customer at a very early stage of business development. In the business model canvas (Osterwalder et al., 2010), the first building block is to define customer segments, indicating that a decision about which segments to cover shall be made carefully. However, the estimation of each segment's volume is not mentioned even if it is crucial for the scaling of a new business. The lean startup (Ries, 2011) presents 3 types of growth engine: sticky, viral and paid. While only the possible ways of scaling a new business are presented, the market potential, i.e. the maximal achievable volume of the market is still unknown. These methodologies provide some guidelines for business scaling, but none of them provides a systematic approach to estimate the market potential for a new business.

New service forecasting is important to support decisions about new service development for companies. Forecasting techniques vary according to the category of new service or product. Crawford and Di Benedetto (2015) recall that the categories for new products are: new-to-the-world products, new-to-the-firm products, existing product line extensions, improvements and revisions to existing products, repositionings, and cost reductions. The new service proposed in the circular economy usually falls into new-to-the-world category, as such service is invented and creates a new market. According to Kahn (2002), new-to-the-world product or service forecasting shows the lowest accuracy and covers the longest time horizon comparing with other categories. It is thus the most strategic and also the most challenging category to forecast. The popular

techniques to conduct new-to-the-world product or service forecasting are with qualitative nature, such as market research, jury of executive opinion, sales force composite, etc. Kahn (2006) furtherly maps most suitable techniques to each category. As the new-to-the-world service forecasting is considered as exogenous, i.e. the future states cannot be deduced from the current situation due to the lack of historical sales data, the quantitative techniques such as time series or regression analyses are not applicable. Scenario analysis combining with judgemental assessment is reported as the most appropriate strategy for new-to-the-world service forecasting. Nonetheless, judgemental techniques are very time-consuming, thus difficult to be deployed to a large extent.

Market selection consists of choosing the right target market for expansion, which is one of the most critical marketing decisions to be made. Techniques applied in this domain are categorised as qualitative and quantitative approaches (Papadopoulos and Denis, 1988). The qualitative approaches are criticised for including potentially biased information and inaccurate subjective judgement. The quantitative approaches are divided into two groups: market grouping and market estimation. Market grouping aims at clustering market subsets with their characteristics chosen according to the needs of decision makers, and does not attempt to measure their potential. It provides market segmentation insights and serves as a pre-assessment tool for market selection (Kimiagari and Montreuil, 2018). Market estimation intends to rank market subsets by order of their potential. Multi-Criteria Decision-Making (MCDM) tools are naturally involved for conducting this ranking as several aspects of market subsets shall be considered simultaneously (Aghdaie and Alimardani, 2015). For market potential estimation in the circular economy, the objectives are somehow different from market selection, but the grouping and ranking techniques are transposable to help with the judgemental assessment.

To the best of our knowledge, a holistic approach does not exist for the market potential estimation in the circular economy, exploring both geographical market conditions and existing product statistics. This paper aims to fill this gap with the following fourfold contribution:

- A framework combining top-down and bottom-up analysis is proposed, by counting explicitly the existing products that can be potentially involved into the new business, and investigating secondary market research statistics.
- Both quantitative and qualitative techniques are explored, where expert judgements, clustering and MCDM techniques are combined.
- The exogenous nature of market potential estimation for new-to-the-world business is fully considered, thus the sales history is not required.
- Decision support systems can be developed based on the proposed framework, to guide service development and market deployment of the new business.

3. FRAMEWORK

The framework proposed to estimate the market potential of a new business in the circular economy is illustrated in Fig. 1. The circular economy context is translated

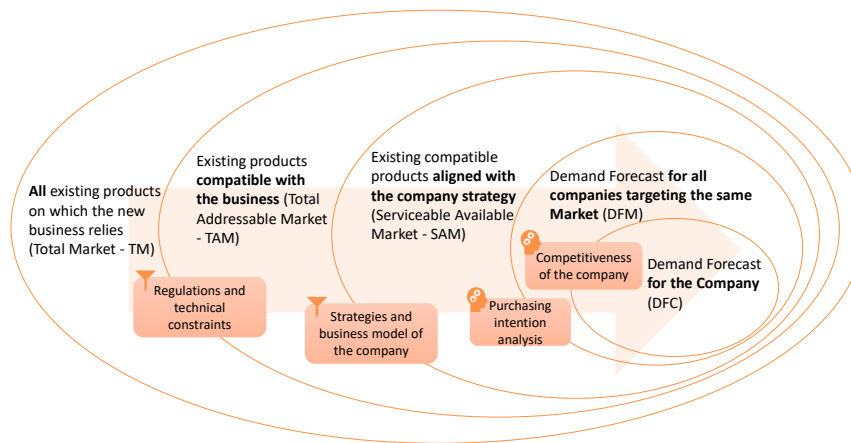


Fig. 1. Market potential estimation framework for a new business in the circular economy.

by the fact that the new business is directly related to a type of existing products, for instance reconditioning of cell phones, retrofit of vehicles, and repurposing of electric vehicle batteries for static energy storage use. Existing products possess different models, which brings complexity to new business proposition in the circular economy. The geographical location of existing products is as well important, as it helps the company to decide where to position their facilities and when they deploy them. The input of the framework shall be thus existing product data containing location and model information, and potential customers information. The input data are then processed to deduce a set of existing products that may be implied in the new business.

The structure of the framework is inspired by common market sizing practices with three metrics (Blank and Dorf, 2012): Total Addressable Market (TAM) indicating the entire opportunity from a market for a given service, Serviceable Available Market (SAM) characterising the part of TAM that can be potentially reached by the service, and finally share of the market representing the part of SAM that can be realistically captured. Two additional metrics are included in the proposed framework to reveal the impact of regulations, technical constraints, and the competition among companies occupying the same market. The five sets to conduct market potential estimation are thus:

- Total Market (TM) including all existing products on which the new business relies,
- TAM which is a subset of the TM, containing the existing products compatible with the business,
- SAM which is a subset of the TAM, containing the existing products aligned with the company strategy,
- Demand Forecast for the Market (DFM), which is a subset of the SAM, containing the existing products of which the owners may be implied in the business,
- Demand Forecast for the Company (DFC), which is the market share of the company in the whole market.

Filters define the procedure to convert a set to its subset. TAM takes regulations and technical constraints into account, as the service provided may not be able to cover all existing products due to technical limitations or regulatory concerns. The company can then impose their strategies or business model to filter the TAM, and that is how

the SAM is obtained. For all existing products in the SAM, the purchasing intention of their owners shall be analysed, and the DFM is obtained. Finally, by estimating the competitiveness of the company in the market, one can get the DFC. Scenario analysis can be conducted at each level by altering parameters used in the filters.

The first filter consists of technical rules required by the business. One can set minimal or maximal permissible values, or other specific rules for the characteristics of the existing products. Geographical location of the products can also be filtered if there are related regulations. The second filter is defined by the company, in which their strategic considerations are involved. A priori decisions can be made on model selection, geographical coverage or owner type. The third filter is a purchasing intention analysis using expert judgement and secondary market research data. The fourth filter uses the competitiveness of the company estimated from expert judgement. The disparity of competitiveness among geographical locations and models shall be captured because the company's presence and maturity are not homogenous.

The implementation of the first two filters is quite straightforward, where conditions are added on several fields of the existing product data. The last two filters are less tangible, with judgemental assessment involved. As mentioned in the previous section, judgemental assessment is time-consuming and sometimes biased, so clustering and MCDM techniques are integrated to improve the efficiency and potentially the quality of judgemental assessment. Only purchasing intention analysis is detailed here, while competitiveness analysis can be conducted by following the similar logic.

The procedure of purchasing intention analysis is presented in Fig. 2. The objective is to estimate a probability for which an owner of existing product will adopt the business, and then deduce the DFM. To do so, the customer behaviour needs to be understood and factors that impact their decisions shall be identified. Customer decision making process is divided into three steps in the stimulus-response model (Kotler et al., 2020). A customer is exposed to stimuli coming from marketing actions or economic, technological, social and cultural environment. The customer then processes the information according to their own background and decision-making habits. How

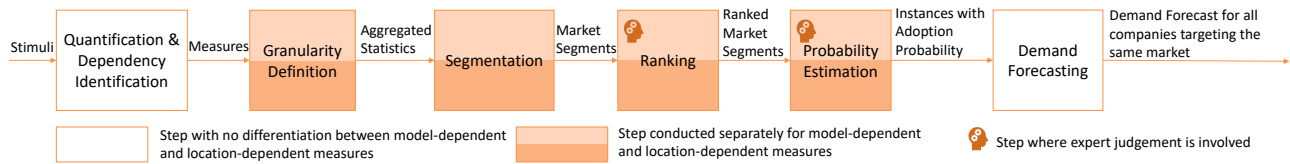


Fig. 2. Purchasing intention analysis procedure in the framework.

the stimuli are processed is considered as a black box. Finally, the customer comes up with a response, which is the decision of purchasing a product and its brand. The key to deduce customer behaviour is to identify the stimuli that trigger the purchasing action.

For purchasing new service relying on existing products, the stimuli come from three origins: the existing product, the potential customer, and the economic, physical and technological environment. From the existing product, the stimuli are the factors that drive the owner to modify or improve their product, and the factors that prevent the owner from choosing another new alternative product. From the potential customer, the stimuli are the motivation to support the circular economy and personal conditions. From the economic, physical and technological environment, the stimuli are external factors that impact the purchasing decision of a customer. For the stimuli coming from each origin, several categories can be expected to help decision makers get a relatively exhaustive list. Such categorisation varies according to the type of existing products. For example, the categories for a new business depending on vehicles can be demography, environment, economy, energy and transport (Zubaryeva et al., 2012).

To carry out quantitative analysis, the stimuli need to be transformed to measures. The measures can be on individual level, or be aggregated by models or geographical locations. The data on individual level are difficult to obtain and process for privacy concern. Aggregated data on geographical location or model level can already bring valuable insights on customer purchasing intentions, thus they are used in this context. The measure for each stimulus can be classified into two types according to its dependency: model-dependent where the measure only shows disparity among different models, and location-dependent where the disparity comes from geographical locations.

The next step is to conduct geographical location segmentation and model segmentation. This can be done by applying clustering techniques on aggregated data. Common clustering techniques include K-Means, hierarchical clustering, etc. (James et al., 2021). Then two sets of market segments can be obtained. The purpose of the segmentation step is to help with judgement assessment, as it is tedious for experts to estimate an adoption probability for each location and each model. With segmentation, experts will only need to provide one judgement for a segment containing similar instances.

Before providing a judgement for each segment, one can further support experts by providing an order of preference for segments. As the preference of a segment shall be judged according to several criteria, which are deduced by the stimuli, MCDM techniques are applicable. One can cite Analytic Hierarchy Process (AHP), MACBETH,

ELECTRE, PROMETHEE, etc. (Figueira et al., 2005). It is to be noted that these MCDM techniques require also expert judgement for determining the importance of criteria and alternatives, but they provide possibilities to quantify intangibles and to compare in relative terms.

With the help of rankings, experts attribute an adoption rate to each segment, which is used as an adoption probability for a model or a geographical location. Each existing product in the SAM can thus have two adoption probabilities, which are the one for its model and the one for its location. The final adoption probability is obtained by multiplying these two adoption probabilities. An adoption decision can be simulated by sampling between True and False with the final adoption probability. The demand forecast is simply the count of all existing products with positive adoption decision.

4. CASE STUDY

A case study is presented in this section to illustrate the application of the proposed framework. The concerned new business in the circular economy is the electric retrofit for Internal Combustion Engine (ICE) vehicles.

To combat global warming and air pollution issues, many countries and cities are coming with restrictions on ICE vehicles. The circulation of ICE vehicles is limited in some cities of France according to their air quality certificate (Crit'Air) classification. Though acquiring a new electric car seems to be an alternative for owners of an ICE vehicle, more affordable solutions are expected to mitigate the impact of restrictions on ICE vehicles. Electric retrofit service is thus proposed as one of the alternatives to accelerate the decarbonisation of automobile industry. A typical electric retrofit service provider is the company Transition-One in France (Transition-One, 2022).

The service consists of converting ICE vehicles into electric ones. The ICE is replaced by an electric powertrain. The fuel tank and the exhaust pipe are replaced by a pack of batteries. The retrofitted vehicle is then tested and certified before being delivered to its owner. Aligned with the circular economy, the electric retrofit extends vehicle lifetime and prompts long-lasting ownership. It contributes significantly to a more sustainable mobility and a more socially responsible society (Mausbach et al., 2020). To accompany the development of this service, the proposed framework is applied to help with its market potential estimation, thus the scaling of electric retrofit business.

4.1 Input Data, Filters and Stimuli Categorisation

The total market shall include all existing ICE vehicles. In this paper, a test dataset containing vehicles located at 5 municipalities in France is used to illustrate the usage of

Table 1. Stimuli matrix for electric retrofit, partially inspired by Zubaryeva et al. (2012)

	From existing product	From consumer	From economical, physical and technological environment
Demography		GDP/capita	Population density; number of households with internet access
Environment	Well-to-wheel GHG emission reduction comparing to alternatives; average temperature in summer; average temperature in winter	Attitude towards climate change	Low-emission mobility zones (ZFE-m)
Economy	Acquisition fee reduction comparing to alternatives; garage accessibility	Household disposable income	Charging point accessibility; access to e-lanes; fuel cost saving vs petrol; fuel cost saving vs diesel; financial incentives; existing demo-projects
Energy			Share of sustainable electricity in net electricity generation
Transport	Commuting behaviour		Car density (cars/1000 habitants)

the framework. The TAM can be calculated by applying a filter on regulations and technical constraints. This filter is composed of two categories:

- Regulatory constraints : vehicle category (L, M, N, not registered as collection vehicle), vehicle age (more than 3 years for category L, more than 5 years for category M, N), vehicle engine (at least one spark-ignition or compression engine), geographical coverage (registered in France).
- Technical constraints : vehicle category (M1, N1), vehicle engine (diesel, petrol), engine power (between 60 kW and 110 kW), and other constraints on weights, noise, CO2 emission, etc.

The vehicle category codes used here comply with the European Union (EU) regulations. L includes 2- and 3-wheel vehicles and quadricycles, M and N indicate vehicles carrying passengers and goods respectively. M1 is a subcategory of M containing vehicles with no more than 8 seats in addition to the driver's seat. N1 is a subcategory of N containing vehicles with maximum mass not exceeding 3.5 tonnes. All attributes listed above are contained in the data of ICE vehicles. The implementation of the filter is simply to apply the conditions on corresponded attributes.

The SAM is deduced by applying a filter on strategies and business model of the company, which can be geographical coverage (urban area), vehicle model selection (age of the model superior to 5 years), and client type (business, customer).

The DFM is deduced from the purchasing intention analysis. For the analysis, the stimuli identified are structured within a matrix (see Table 1) where their origins and categories are specified.

The stimuli are then quantified by statistics if possible. For the case of France, the granularity chosen is municipality, as it is the finest unit for many statistics studies conducted by Institut national de la statistique et des études économiques (INSEE). To give an example, the commuting behaviour is quantified by median commuting distance for employed persons and for commuters (in km) of each municipality.

4.2 Market Segmentation, Ranking and Demand Forecast

Market segmentation is conducted using aggregated statistics on municipality level and vehicle model level. Geo-

graphical location segmentation is done on French territory as regulations used in the first filter require the registration country of vehicles to be France. Clustering analysis is carried out on municipality level statistics. It provides clusters of municipalities showing similar characteristics. K-Means clustering is adopted in this case, implemented using scikit-learn library (Pedregosa et al., 2011). Preprocessing and dimensionality reduction are performed before clustering step. The number of clusters is selected by maximising the silhouette score. A similar clustering analysis can be done on vehicle model level.

To help experts estimate adoption rate for each cluster, AHP is used to rank clusters according to their electric retrofit business potential, where criteria are the aggregated statistics, and alternatives are clusters of municipalities. Expert judgement is integrated by making reciprocal pairwise comparisons among criteria and alternatives. A rank of clusters is finally proposed and visualised on a map (see Fig. 3), where the colour scale corresponds to the preference of clusters in terms of electric retrofit business potential. Similarly, ranking can be conducted on vehicle model clusters with the same method.

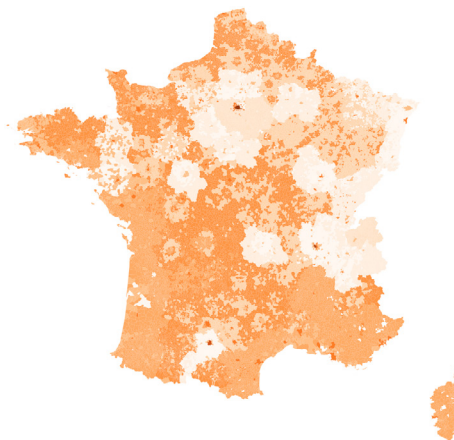


Fig. 3. Choropleth map of France for market potential of electric retrofit

The visualisation on Fig. 3 shows only Metropolitan France. On the map, the darker the colour, the greater the electric retrofit market potential is supposed to be. According to the analysis, municipalities demonstrating more potential for developing retrofit business are with high GDP per capita, moderate income, high population

density, relatively low temperature in summer, moderate temperature in winter, relatively low mobility emission, low commuting distance, and with charging infrastructure.

Experts are invited to estimate an adoption rate on each cluster. This adoption rate is used as an adoption probability for each vehicle situated in the cluster. Finally, an adoption decision for each vehicle is simulated from the adoption probability. By applying the described process on the test dataset, numbers of vehicles for each set are calculated for 5 municipalities (see Table 2). The results show one scenario. Other scenarios can be generated by altering conditions in filters and expert estimations. It is assumed that there is only one company in the market, so the DFC is the same as the DFM.

Table 2. A scenario for market potential estimation with test dataset

Municipality	TM	TAM	SAM	DFM	DFC
Paris	490,370	126,087	100,350	30,170	30,170
Toulouse	239,035	60,015	48,088	9,240	9,240
Orléans	57,230	14,440	11,521	1,185	1,185
Albi	32,070	8,006	6,348	887	887
Saint-Denis-de-l'Hôtel	2,470	628	-	-	-

5. CONCLUSION AND FUTURE WORK

The framework proposed in this article answers the following question: How to estimate the market potential of a new business in the circular economy? It is a systematic approach combining expert opinions with statistical methods. Geographical market deployment plan and service development plan can be elaborated from the approach. A case study on electric retrofit service is introduced to show the application of the framework.

Future perspective involves full implementation of the case study with vehicle registration system data, as well as the conception of decision support systems to help with new business scaling under the circular economy context. These decision support systems should contain quantitative measures to explicitly demonstrate the impact of business decisions on the circular economy. Additionally, the proposed framework holds potential for applications across various industries. Furthermore, the design and deployment of the supply chain network for a new business in the circular economy shall be investigated.

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